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PHASE II

POSTATTACK SANITATION, WASTE DISPOSAL, PEST AND VECTOR CONTROI AND THE EFFECTS OF FALLOUT IN WASTE WAT AND SEWER SYSTEMS

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U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
SAN FRANCISCO, CALIFORNIA

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Work Unit 3441A
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This report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

By

Engineering-Science, Inc.
150 East Foothill Blvd.

ABSTRACT

This study presents information on the magnitude, character, and timing of postattack sanitation operations for the San Jose Metropolitan Area of California and assesses the effectiveness of these overall operations on maintaining disease incidence at levels which will not be detrimental to postattack recovery. It also presents information on the sedimentary effects of fallout washed into drainage systems including: (1) a method to determine the effects; and (2) the sections of the systems which are most likely to experience sediment build-up.

The results of the analysis of the postattack sanitation operations in the Study Area indicate approximately 60 percent of the waste collection vehicles will be damaged, but due to increased use of the surviving vehicles and the postattack reduction of household refuse production, no detrimental effect on the overall postattack recovery of the area is expected.

The study of fallout transport in drainage systems indicates that sediment build-up will occur when the flow rate per unit of width is decreased, as in the case of water exiting from a catch basin connector pipe into a main line.

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SUMMARY

The objectives of this study are to examine, in depth, a specific geographical area and to: (1) develop the magnitude of the postattack sanitation requirements; (2) develop the character of effective postattack sanitation procedures; (3) present a time sequence for implementing the procedures; and (4) assess the effectiveness of the proposed countermeasures. Further objectives are to develop information concerning: (1) the sedimentary effects of fallout washed into municipal drainage systems; (2) the sediment concentrations of flows reaching the system; (3) the location and probability of potential stoppages; and (4) the flows required to eliminate sediment deposition.

SANITATION RECOVERY

The San Jose Metropolitan Area was selected as the Study Area in which to apply and test the postattack sanitation recovery techniques developed in Phase I under an earlier contract (OCD-PS-64-9). Although this report is not intended to be part of the Five City Study, Weapon 154 of the Five City Study Scenario was applied to the Study Area to establish a postattack environment because of the readily available information on the City of San Jose.

The preattack solid organic waste production in the Study Area is estimated to be approximately 7,700 cubic yards per day during the summer months. Approximately 3,000 cubic yards of the total are wastes from the local canneries. Regular sanitation companies and special cannery waste haulers use 226 trucks and 440 men in the collection of these wastes. The regular companies normally work 5.5 days per week (44 hours per week), while the special companies work about 20 hours per day, seven days per week. There are 13 disposal sites in the Study Area which require 25 crawler-type tractors, eight draglines, and 35 men to operate them preattack. Mosquito, fly, and rodent control operations are guided by the local health departments, with much of the work being performed by private exterminator companies and individual householders.

Based on the assumed weapon effects, approximately 60 percent of the waste collection vehicles, 40 percent of the tractors, 100 percent of the draglines, 70 percent of the sanitation company offices, and 30 percent of the vehicle maintenance buildings will be damaged to a degree that will preclude their use early postattack. It is assumed that about one-half of the surface roads will be impassable to vehicles due to debris.

This study assumes there will be no nightsoil production because the population will leave shelters when they realize that no fallout has been created by the assumed weapon. It is estimated that a minimum of 68,500 cubic yards of solid organic waste would require collection and disposal in the first week postattack. This would create the following logistical requirements: (1) 150 collection vehicles working 16 hours per day for seven days; (2) 13 tractors; (3) 8,300 gallons of fuel; and (4) 642 workers.

FALLOUT TRANSPORT

The development of information regarding the sedimentary effects of fallout on drainage systems is based on the fundamental assumption that the transport of this sediment is analogous to the familiar bed-load movement which occurs in the sand beds of natural streams. All components of the drainage system are assumed to have a sand bed over which a relatively shallow and wide flow of water is traveling. From this basic assumption, and the application of Einstein's theories[7], curves have been developed which show sediment transport rates as functions of particle diameter, rate of flow per unit of width, and conduit slope. On the basis of the same theory and assumption, curves have been developed which give the hydraulic characteristics for various flow rates, slopes, and particle diameters.

Flows originating from natural rainfall or wet decontamination procedures are studied in three phases: (1) fallout transport to an inlet structure; (2) transport through the inlet structure; and (3) transport in the pipes comprising the system.

CONCLUSIONS

The logistics of the postattack sanitation operations are impeded by the damage effects of the assumed weapon. The collection and disposal of solid organic wastes should receive the first priority, followed by mosquito and fly control. Because of a possible lack of fuel and an estimated

30 percent deficiency in the number of vehicles required to collect the predicted wastes, there is expected to be a significant amount of uncollected wastes in the Study Area at the end of the first week postattack. This will create favorable fly breeding conditions. However, the enteric diseases, which flys can transmit, will not be as detrimental to the surviving population as they could be if the flys had access to uncollected nightsoil from shelters. A well formed operational plan and administrative organization are necessary to fully implement the suggested procedures. However, the gross effect of the deficient sanitation capabilities, expected to be available in the Study Area postattack, probably will not create a disease incidence level which would seriously damage postattack recovery.

The parameter which can cause the greatest variation in the sediment transport rate is the fallout particle diameter. The relative difference in the sediment transport and supply rates for a particular section of a system is indicative of whether or not sediment build-up will occur. Sediment deposition will occur when the rate of flow per unit of width is reduced, as in the case of water entering a catch basin from a gutter or entering a main line from a connector pipe. Wet decontamination procedures are more likely to create sediment build-up than storm flows because of their high velocity and relatively short duration. There may be a few occurrences of sediment build-up from fallout being washed into a drainage system, but these instances probably will not damage the gross effectiveness of the system's functional capability.

RECOMMENDATIONS

It is recommended that further study and analysis be given to: (1) the transport of fallout by overland sheet flows created by rainfall; (2) the transport by storm flows in streets; and (3) additional actual drainage systems to develop more data on the sedimentary effects of fallout.

CHAPTER I

INTRODUCTION

In the event of nuclear attack on the United States, survivors may be exposed to endemic diseases capable of rapid development in an uncontrolled environment. A study of conditions that may prevail postattack shows that there are some 14 diseases of man that may increase sharply to epidemic levels in the early postattack period. With the effective application of countermeasures, disease epidemics can be prevented and localized outbreaks confined to small segments of the surviving population with little over-all effect on the nation's recovery.

A part of the postattack effort must, in addition, provide for the removal of the mass of fallout material from areas of habitation and recovery operations to (1) protect survivors from the radiation hazard and (2) restore surfaces (structures, equipment, yards, and streets) to a usable condition. In doing this, the effect of the radiation associated with the material as well as the physical effects of the material must be considered. This study of the effects of fallout on municipal waste water and sewerage systems relates primarily to the physical effects of the material.

STUDY OBJECTIVES

The objectives of this study are to examine, in depth, a specific geographical area and to: develop the magnitude of postattack sanitation requirements; develop the types of effective postattack sanitation procedures; present a time sequence of operations related to the response of the environment to the assumed attack; and assess the effectiveness of the proposed countermeasures.

Further objectives are to develop information concerning the (1) sedimentary effects of fallout washed into drainage systems, (2) water-solids ratio of flows entering the systems, (3) frequency and magnitudes of potential stoppages, (4) location of stoppages, and (5) the flows required to eliminate sediment deposition.

SCOPE OF WORK

This study required the performance of the following tasks:

(1) Determination of preattack disease endemicity and sanitation capabilities for a specific area.

(2) Assessment of postattack sanitation requirements based on an evaluation of postattack sanitation problems and disease hazards.

(3) Development of a method to analyze the sedimentary effects of fallout washed into a drainage system.

(4) Study of a line of drainage in a specific drainage system.

(5) Development of information regarding the effects of fallout washed into drainage systems that will aid in the management of postattack recovery operations.

METHODS OF STUDY

The performance of the above tasks required utilizing knowledge and experience gained from a previous study "Postattack Sanitation Waste Disposal, Pest and Vector Control Requirements and Procedures," which was performed under Contract No. OCD-PS-64-9, as well as collection of much data in the field. Based on research of available literature, an approximate method of analysis was devised which allowed the effects of fallout on drainage systems to be evaluated. From this study, general information was developed regarding these effects and the malfunctions that may occur in a drainage system due to fallout deposits.

This study is not intended to be a Five City Study report. The City of San Jose was chosen as a vehicle to apply previously developed techniques because of the large amount of readily available information pertinent to the subjects discussed herein.

CHAPTER II

PREATTACK SANITATION ACTIVITIES

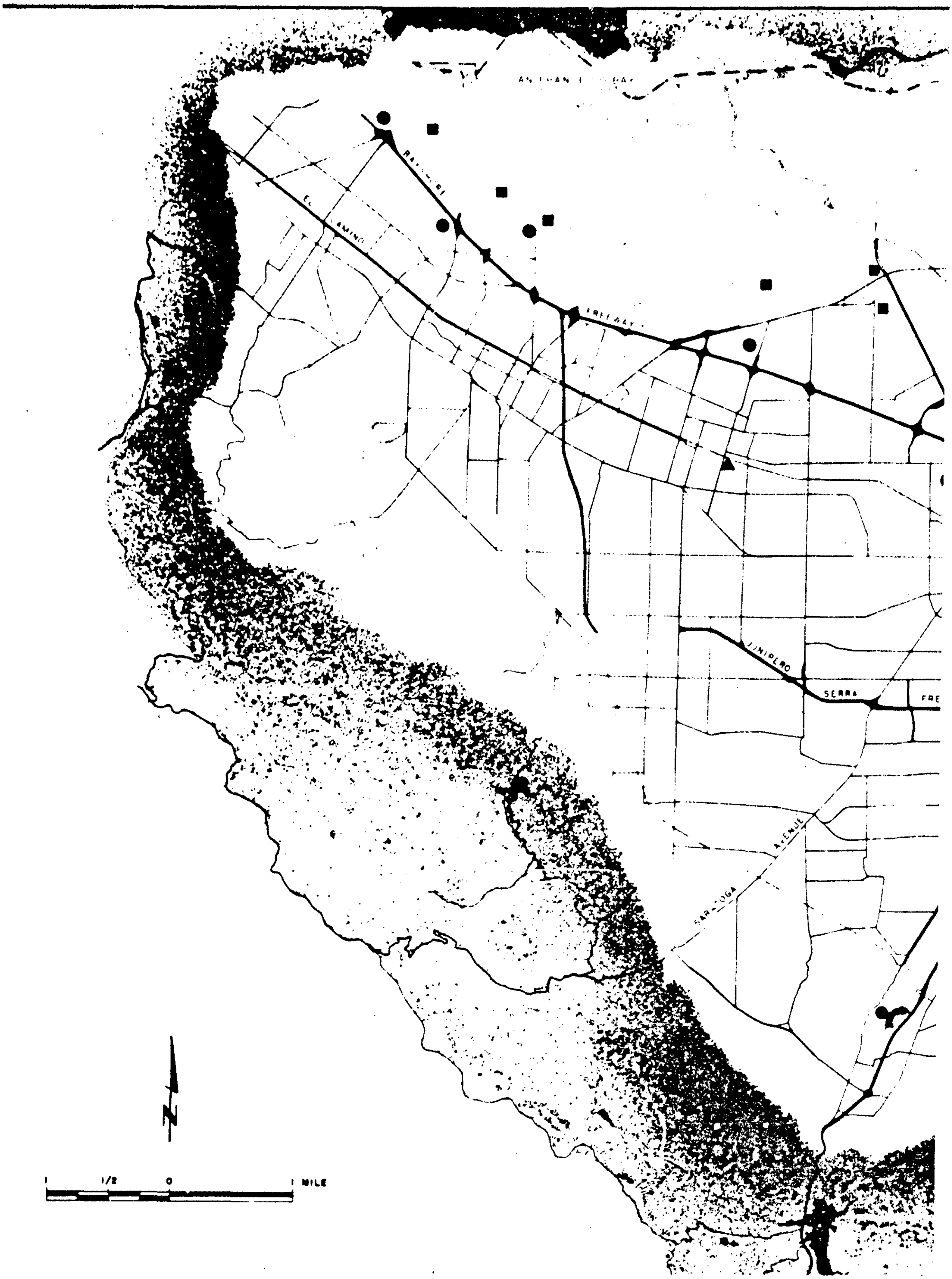
STUDY AREA

The San Jose Metropolitan Area of California has been selected as a representative site to apply and test postattack sanitation recovery techniques as presented in general in Reference 1. The limits of the Study Area have been established to include the service areas of (1) the primary disposal companies in the vicinity of San Jose and (2) the areas under control of the various vector control agencies. In addition, the locations of the primary disposal sites are also within the Study Area. Figure 1 provides a pictorial representation of the Study Area and also shows the relative locations of the major points of interest.

The topography of the area can be characterized as a flat valley bordered on the east and west by low ranges of hills. Surface water drains from the hills into the valley and thence northerly to the marsh lands of the Southern San Francisco Bay. The climate of the Study Area is generally moderate with a mean high temperature of approximately 75°F to 80°F in the month of August. There is no weather station in San Jose; however records of stations in the nearby Cities of Palo Alto and Los Gatos indicate that little or no precipitation occurs in the summer months.

The environment of the Study Area is generally urban. Residual agricultural and associated food processing operations are important to its economy. Agricultural operations within the area include deciduous fruit and berry orchards and vegetable farms. Food processing plants include canneries, frozen food processing plants, fruit and vegetable packing sheds, feed and grain mills, meat packing plants, and milk products plants. Livestock and poultry operations encompass dairies, cattle, sheep, and hog ranches, cattle feed yards, and poultry (chicken, turkey, duck) ranches.

The present population within the Study Area is estimated to be approximately 600,000.



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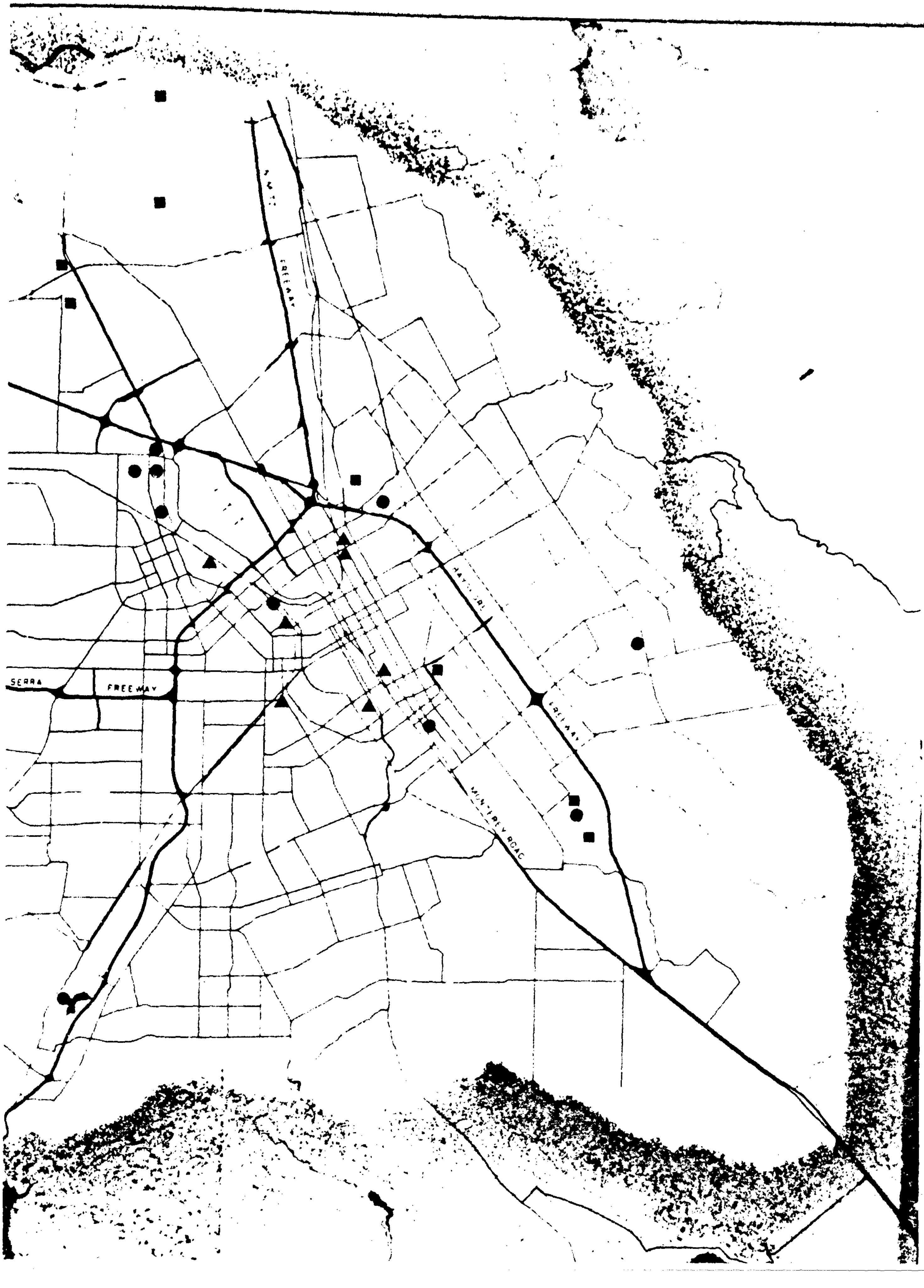
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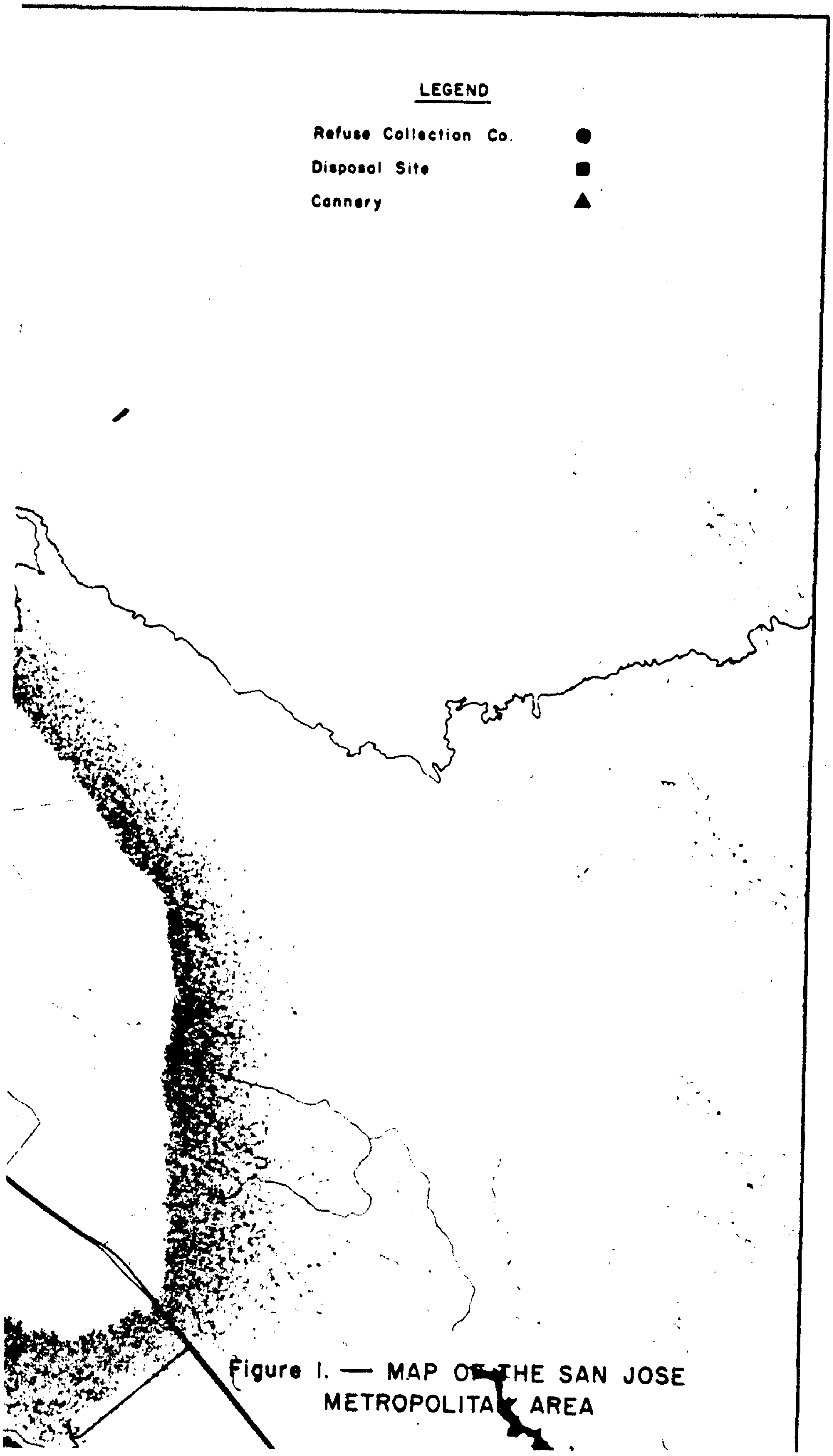


Figure 1. — MAP OF THE SAN JOSE METROPOLITAN AREA

The urban-rural vector environment includes rodent harborages, filth fly breeding sources, mosquito breeding areas (drainage channels, streams, and ponded agricultural and industrial waste waters), organic and inorganic waste disposal facilities, and garbage and other wastes in storage or transit.

WEAPON CHARACTERISTICS

Although this report is not intended to be part of the Five City Study, the phase of this study concerned with postattack sanitation requirements assumes the detonation of Weapon 154 of the Five City Study Scenario because of information that was readily available on the City of San Jose. The assumed nuclear weapon is detonated at 8:52 p.m., 24 August 1965, at an altitude of over 2.5 miles at a location northeast of the downtown area of San Jose. The weapon is assumed to have a yield of five megatons and thus could create, in the heart of the Study Area, overpressures and thermal radiation effects of the order of magnitude of 10 pounds per square inch (psi) and 10 calories per square centimeter (cal/cm^2), respectively. However, because of the assumption that the explosion is an airburst, it is further assumed that the weapon creates no fallout, and therefore the postattack sanitation capabilities in the Study Area will not be affected by fallout gamma radiation. Also, because of the height of the burst, it is assumed that there would be no damaging effects from initial radiation.(2)

PREATTACK DISEASE ENDEMICITY

The diseases hereafter discussed are important to this study because they are related to environmental sanitation conditions that can be significantly influenced by a nuclear attack and the resulting waste disposal, and pest and vector conditions in the postattack period. The enteric infections are of primary concern due to the immediate close contact of human survivors under the assumed postattack conditions.

Enteric Diseases

The five enteric diseases (Shigellosis, Salmonellosis, Infectious Hepatitis, Typhoid, and Amoebiasis) have high factors of endemicity because of their relatively high prevalence in the area, the potentially high fly population, and because of their relative ease of transmission and introduction.

Rodent Borne Diseases

Although Leptospirosis is fairly common in most domestic rats and animals and may become more hazardous with an increase in the rodent population, it will, initially, be unimportant. Murine Typhus has not been found either in humans or in rodents in the Study Area for many years.

Plague is endemic in nearby San Mateo County among small field mice, and was found repeatedly in ground squirrels in the Santa Clara Valley in 1945. Domestic rats were recently found in a sylvatic plague area in San Mateo County, which suggests a potential hazard to Santa Clara Valley.

Mosquito Borne Diseases

Although culex tarsalis, the mosquito vector of Encephalitis, is found near San Jose, few human cases have been reported in the area. Occasional cases in horses have occurred. Human cases have rarely occurred in similar coastal areas in California.

Dengue Fever and Yellow Fever have never been known to occur naturally in the county. Aedes aegypti, the vector of these diseases, is not found in the State, and the Study Area is not considered to be naturally receptive to the promulgation of these diseases.

Although the anopheline mosquito vector of Malaria occurs in the area and Malaria infected individuals have been found, no recent cases of indigenous Malaria have occurred. This may be due to the relatively mild summers, chilly winters, and the scattered occurrence of anopheline mosquito breeding sources.

Miscellaneous Disease Problems

Rabies has been found in overt wild animals and recently was found in a horse. This disease can become a significant hazard if dogs are allowed to run loose and mingle with the infected wild animals.

Only one case of Rocky Mountain Spotted Fever has been reported in Santa Clara County in the last ten years. Although the tick vector is found in the Study Area, the natural areas for its occurrence are diminishing with the onslaught of urban development.

PREATTACK SANITATION CAPABILITIES

Organic wastes management is the most important sanitation activity to be considered in this study. Organic wastes include household combined refuse and commercial-industrial wastes which are collected and hauled to various disposal sites. This study is not concerned with the organic wastes which are normally transported in the sanitary sewer system.

Organic Waste Production

There are two basic categories of organic wastes -- household refuse (rubbish and garbage) and commercial or industrial wastes (swill, cannery wastes, paper, etc.).

Based on an inventory of the waste collection companies in the Study Area, it is estimated that the average daily production of household refuse is approximately 3,100 cubic yards. The average daily production of commercial and industrial wastes (excluding cannery wastes) is estimated to be approximately 1,600 cubic yards. During the canning season (which extends from June 1st. to October 30th.), the average daily production of waste from canneries is estimated to be approximately 3,000 cubic yards. Table I shows the estimated average organic waste production quantities. It should be noted that the peak month for cannery operations is August, when apricots, pears, prunes, and tomatoes are harvested.

TABLE I

STUDY AREA SOLID ORGANIC WASTE PRODUCTION

Item	Solid Waste (Cubic Yards/Day)
Household Refuse	3,140
Commercial-Industrial Wastes (includes approximately 140 cubic yards of paper wastes)	1,550
Cannery Wastes (Only from June through October)	3,000
TOTAL	7,690

Refuse Collection

The collection of household, commercial, and industrial wastes within the Study Area is accomplished by private collection companies, with one exception. The exception is the City of Santa Clara where all household refuse, except garbage, is collected by the City and the garbage is collected by a privately operated company.

There are 11 sanitation companies which regularly serve the Study Area households with collection service (normally on a once per week basis). The normal commercial and industrial collections are made on the basis of need, which may vary from once per week to daily. In addition to these 11 companies, four specialized haulers collect and dispose of large amounts of waste created by the canneries during the canning season. These specialized companies function only during the canning season and usually work 20 hours per day during that period. Figure 1 shows the locations of the various sanitation companies and special haulers as well as the locations of the important canneries. Table II shows an inventory of collection equipment and manpower that make up the organic waste collection force.

TABLE II

STUDY AREA WASTE COLLECTION EQUIPMENT AND MANPOWER

Company	Total Trucks	Automatic Packer Trucks	Open Trucks and Others	Trucks In Normal Use	Total Personnel
1	12	10	2	12	15
2	9	7	2	7	9
3	13	10	3	11	23
4	51	32	19	40	98
5	14	14	--	11	49
6	20	18	2	18	34
7	13	12	1	11	22
8	17	17	--	16	31
9	38	30	8	38	68
10	16	11	5	16	24
11	11	11	--	9	10
Subtotal	214	172	42	189	383
12*	12	--	12	9	13
13*	14	--	14	14	18
14*	10	--	10	10	22
15*	6	--	6	4	4
TOTAL	256	172	84	226	440

* Special companies hauling cannery wastes.

The automatic packer trucks vary in capacity from 18 to 38 cubic yards and are used as the standard collection device for the disposition of normal household, commercial, and industrial wastes. The "open" or "other" trucks noted in Table II are used to supplement the automatic packers and to haul the cannery wastes. The trucks indicated "open" or "other" are pickups or diesel tractors pulling trailers.

The normal work week (for all but the special cannery waste haulers) is 44 hours. Typically an automatic packer truck requires two men to operate it and the other trucks require one. However, some of the larger packer-type trucks use three men, a driver and two loaders, for maximum operational efficiency.

It is estimated that the 189 vehicles in normal use travel about 25,000 miles per week in the course of collection and disposal of the organic wastes. Assuming the average gasoline consumption to be approximately at the rate of 10 miles per gallon, an estimated 2,500 gallons of fuel is used each week. This amount is somewhat difficult to estimate because of the various types of vehicles and because gasoline, butane, and diesel are all used as fuels. On the same basis, the special cannery waste haulers will use an estimated 2,100 gallons of fuel each week. Most of the fuel is stored underground and pumped to vehicles. The existing storage capacity would supply fuel for at least a week, assuming the normal rate of use.

The plant facilities of the sanitation companies usually consist of: a large yard where vehicles are parked in the open at night, or when not in use; a wood frame office or administration building; a maintenance shop housed in a metal shed-type building; fuel storage facilities; and, in most cases, a block wall or chain link fence surrounding the property.

The repair and maintenance of the equipment (including the special cannery waste haulers) is normally done by the companies themselves at their yards. Typically they maintain very few, if any, spare parts for replacement because of the availability of parts from nearby commercial suppliers and the unwarranted costs involved in maintaining large and complete inventories.

There is no tvpical or normal method of maintaining communications with the collection vehicles while they are in use. A few companies have radio controlled units, while most do not.

Table III has been prepared to show the total capability of the sanitation companies and special cannery waste haulers.

TABLE III

STUDY AREA SANITATION CAPABILITIES

Company	No. of Trucks Normally Used	Personnel Used	Cu. Yd. of Organic Wastes Normally Hauled Per Week [(a)]	Normal Hours Worked Per Week
1	12	15	500	44
2	7	9	750	"
3	11	23	900	"
4	40	98	9,200	"
5	11	49	4,800	"
6	18	34	2,500	"
7	11	22	3,000	"
8	16	31	3,400	"
9	38	68	5,200	"
10	16	24	1,900	"
11	9	10	1,620	"
Subtotal	189	383	33,770	"
12 [(b)]	9	13	11,000	140
13 [(b)]	14	18	3,300	"
14 [(b)]	10	22	5,600	"
15 [(b)]	4	4	1,300	"
TOTAL	226	440	54,970	--

(a) Includes household, commercial, and industrial solid organic wastes.

(b) Special cannery waste haulers.

From Table III it can be seen that the sanitation companies working 44 hours per week and that two men with one truck can collect and dispose of approximately 180 cubic yards of solid organic waste material. Assuming that the special cannery waste haulers work two and one-half shifts (20 hours) seven days per week, then one of these vehicles can collect and dispose of about 573 cubic yards per week. A comparison of these two operations shows that each truck is capable of collecting and disposing of approximately 180 cubic yards every 44 hours. The special haulers can operate a collection vehicle with less manpower because the collection of the cannery wastes is done at concentrated locations.

Refuse Disposal

The Study Area contains 13 disposal sites which are operated as sanitary landfills. Figure 1 shows their locations and it should be noted that several are located very close to the southern section of San Francisco Bay. These particular sites are protected from inundation by an eight foot dike.

The 15 collection companies discussed above transport solid organic wastes to these various sites. Specific sites are chosen for a variety of reasons, the most important probably being the proximity of the site to the collection area.

The majority of the sites have good access roads and at least one alternate route is available should the primary one be unusable. The disposal sites are typically operated six days per week, although they may be open for dumping seven days per week. Table IV shows the salient items of information regarding these facilities.

The tractors on the sites are crawler types utilizing bulldozer blades and/or compactors. Draglines are used for excavation in areas where the groundwater table is so high that the tractors cannot operate. Repair and maintenance of disposal equipment is carried on at the disposal sites as necessary. In the case of the draglines some replacement parts must be obtained from other areas in the United States.

TABLE IV

STUDY AREA DISPOSAL SITE OPERATIONS

Site No.	No. of Tractors	No. of Draglines	Manpower
1	2	--	2
2	2	1	2
3	2	--	2
4	2	1	3
5	2	--	5
6	2	--	3
7	2	2	3
8	2	1	2
9	2	--	4
10	1	1	2
11	2	1	2
12	2	--	3
13	2	1	2
TOTAL	25	8	35

Domestic Fly Control

The local city and county health departments maintain surveillance of known fly breeding sources such as: chicken ranches, cattle feed lots, riding academies, canneries, waste disposal sites, and waste collection equipment. During the season of intense fly breeding, these sources are routinely inspected and the operators are given instruction in the application of effective control measures. Occasionally these health department activities include limited demonstrations of control measures. When source limiting control measures are not effective, private pest and vector control operators may be employed to use chemical sprays on an interim emergency control basis. There are numerous such companies in the Study Area and an ample supply of chemicals is available.

Mosquito Control

The local health departments maintain a source surveillance program and can exercise limited control measures against the mosquito population. The San Jose City Health Department maintains a staff of five men and the county has seven men for the purpose of implementing this program. Public property receives routine vector control from these agencies, while private property receives only emergency or short-term control.

In addition to the health departments, the flood control district, water conservation district, and public works departments of the Study Area all incorporate mosquito source reduction in their programs.

The San Jose City Health Department has the following specialized equipment: one blower; two hose rigs; and one tractor powered spray rig with a storage tank. The Santa Clara County Health Department stores 40 percent of their equipment at a yard in Palo Alto and the balance at a yard in San Jose. The materials available in storage from these health agencies would normally last an estimated two months.

Rodent Control

The local health departments in the Study Area have inventoried the sources of rodents requiring continuing surveillance and control measures. The central part of Santa Clara County has a resident population of roof rats that exist in trees and shrubbery. The health departments supply the householders with poison and advise them in its use.

In those sections of the Study Area where extensive sewage collection systems exist, sewer rats are prevalent, especially in the older lines. In the areas of heaviest infestation it has been estimated that there are an average of ten to twenty rats per block. Control measures consist of health department personnel baiting the sewer lines with poisons about every six months.

Cattle feed lots and poultry ranches in the area experience a rat problem and require suppression measures such as protective construction and poisoning. Private exterminator companies are usually retained to carry out the control measures at these sources.

Rodent control in the Study Area is maintained through: (1) the routine inspection and demonstration activities of the local health departments; (2) the programs of the local public works departments, sewer districts, and agriculture commissions; and (3) the work of hired private exterminators and individual householders.

CHAPTER III

ASSESSMENT OF POSTATTACK SANITATION REQUIREMENTS

DAMAGE TO THE ENVIRONMENT

The effects from damage caused by the assumed nuclear weapon on various phases of the environment in the San Jose Metropolitan Area will dictate, to a certain degree, the nature and extent of the postattack sanitation operations that would be required in order to maintain disease endemicity and incidence rates at preattack levels. As stated earlier, the assumed weapon will create blast and fire damage, but will not cause fallout. Within a radius of approximately three to five miles[3] there will be a very high degree of destruction. Beyond this range, however, the degree of damage will proportionately diminish until, at approximately 11 miles[3] from ground zero, the damage will become slight.

The damage to the environment can be catagorized as follows: (1) damage to the materials and equipment necessary to effect required postattack sanitation operations; (2) damage to structures, utilities, trees, etc. which will effect the logistics of the postattack sanitation operations; and (3) damage to the environment which will create habitats favorable to the breeding and growth of the various disease vectors and hosts.

Effects on Sanitation Equipment and Facilities

The assessment of the nature and extent of the damage to sanitation equipment and facilities required: (1) a descriptive inventory of various items to be considered; (2) definition of the degrees of damage; (3) a study of the ways the various objects incur damage; and (4) a method of determining the extent of the damage.

The equipment considered basic to the functional operation of organic waste management programs in the Study Area includes collection vehicles, crawler-type tractors, draglines, and other miscellaneous equipment. The vehicles are packer-type trucks and other "open" type trucks.

In order to maintain a degree of consistancy with other studies of this nature, the classifications of damage presented in Reference 2, page 166, have been adopted for equipment considered in this report. Classifications are severe, moderate, and light degrees of damage to various equipment items. For the purposes of this study any damage of a moderate degree or higher degree will be assumed to have rendered the vehicle non-functional as regards its potential use in the early phases of postattack sanitation operations. This assumption seems reasonable because any major repairs required to be made to a vehicle probably could not be effected for at least several weeks after the assumed attack, and the critical need for such collection and disposal equipment will be in the first few days following the attack.

The sanitation equipment under consideration (trucks, tractors, and draglines) incurs damage because overpressure from the weapon will cause bending, twisting, and breaking of various component parts. In addition, this equipment can suffer damage due to collision with airborne missiles and other objects, overturning, and fire.

Packer trucks of capacities of 20 to 38 cubic yards can be expected to be overturned and/or pushed sideways at overpressures on the order of one psi. This assumes that the blast wave from the weapon is incident to the side of the vehicle. If the blast wave is incident to the front or back of this type of vehicle, overpressures in magnitudes of 2 psi will be required to slide the vehicle forward or back, as the case may be. Following the definitions for the degree of damage stated above, Reference 1, page 175, shows that moderate damage to the trucks will be incurred at approximately 32,000 feet from ground zero. Intensities of blast overpressure have also been determined from Reference 1 for use in developing the assessments of degrees of damage. The same source also shows that construction equipment (tractors of the type commonly used at the disposal sites in the Study Area) will suffer damage of a moderate degree at a distance of 20,000 feet from the blast center.

The information presented in Table V is based on an actual inventory of the numbers and types of each item of equipment, their locations, and an estimate of the probable kinds and degrees of damage.

TABLE V

DAMAGE ASSESSMENT OF STUDY AREA SANITATION EQUIPMENT

Item	Total Number	Percent Non-Functional Postattack	Number Functional Postattack
Automatic Packer Truck	172	65%	60
Open Trucks and Others	84 (a)	45%	46
Tractors	25	40%	15
Draglines	8	100%	Zero

(a) Includes Special Cannery Waste Hauling Equipment.

A higher percentage of automatic packer trucks are assumed damaged than the "open trucks and others" category for several reasons. The packer-type has a larger frontal area (approximately 56 sq ft) and a larger side area (approximately 200 sq ft) than most of the other vehicles and is therefore affected more by any given level of overpressure. The large metal bodies of the packer-type do not add weight to the vehicle in the same proportion that they add area. Another reason that a higher precentage of damage is suffered by the automatic packers is that several of the sanitation companies have maintenance yards close enough to the blast center to expect total destruction. The special haulers of cannery wastes, who have trucks only in the "open or other" category, are not located close enough to the blast center to expect that degree of damage to any of their vehicles.

Table V also indicates that all of the draglines will be damaged to a degree that will render them useless for the period of time required to repair the booms. It is expected that the booms will be the component most sensitive to blast and because of the draglines being located in regions of relatively high overpressure it is reasonable to expect this degree of damage.

The sanitation facilities described in Chapter II consist basically of wood-frame structures housing the administrative and business offices of the collection companies and light steel frame metal buildings housing the maintenance facilities.

Damage classifications for these structures have been taken from Reference 1, pages 159 and 160. The classifications are severe, moderate, and slight. For the purposes of this study, any degree of damage of moderate or higher will be considered as precluding the use of the structure within the early postattack period when the highest critical need for sanitation measures exists.

The estimated degree of damage to the wood-frame office structures and metal maintenance buildings is based on the information from Reference 1, page 173. This source shows that for the wood-frame structures a moderate degree of damage will be expected to a range of approximately 60,000 feet from the blast center. Similarly, for the metal maintenance buildings, the range is approximately 32,000 feet.

On the basis of the above, it is expected that of the 15 collection companies in the Study Area, only four (approximately 27 percent of the total) will have business offices in which they can function subsequent to the blast. However, 11 of the 15 maintenance buildings will be left sufficiently intact to allow their use for their intended purpose.

The effects of thermal radiation and the resulting fires have not been emphasized in this study because most of the equipment and facilities are in areas not prone to the probability of a fire-storm. The trucks are parked in open yards and the structures usually have much open area surrounding them.

TABLE VI

SANITATION EQUIPMENT AND FACILITIES REMAINING POSTATTACK

Item	Percent Remaining Postattack	Number Available Postattack
Automatic Packer Trucks	35%	60
Open Trucks and Others	55%	46
Tractors	60%	15
Draglines	Zero	Zero
Administrative Offices	27%	4
Maintenance Buildings	73%	11

A summary of the numbers of equipment items and sanitation facilities remaining after the weapon detonation is given for the Study Area in Table VI. This information will be used as a basis for determining the required operational procedures in the early postattack period.

Effects on Disease Reservoirs

One of the major effects of the assumed weapon on the Study Area, due to the debris created by the blast and the disruption of the normal sanitary services, will be the creation of breeding and harborage areas which allow the increase of disease vectors (flies, rodents, mosquitoes, and ticks). For example, mosquitoes will find new breeding locations in casual ponds of water created by debris blocking natural drainage courses. Dogs left unattended will become infected with rabies after contact with infected wild animals in the area. With the probable loss of postattack electrical power, lift stations in the sewage collection and treatment systems will cease to function. This will cause raw sewage to back up. The areas devastated by the blast and left vacant will allow wild animals and rodents to infiltrate and find new breeding grounds. Areas of intense debris and rubble also provide habitats for the wild animals and rodents.

The blast and thermal radiation from the assumed weapon will create concentrations of organic waste material at damaged canneries and stockyards. This organic material will provide a habitat for fly breeding. The same holds true for poultry ranches where thousands of chickens and turkeys would be killed by the blast and provide a large new breeding ground for flies. The probable loss of electrical power will cause refrigeration to fail and thereby create more organic wastes which will increase the fly population. Other stored food supplies will be left exposed to the elements because of blast and fire damage to warehouses. All of these damage effects provide new areas and locations which allow a very significant increase in the fly population.

Effects On Logistics

The movement and supply of personnel charged with the responsibility of performing postattack sanitation operations in the Study Area will be affected by the assumed weapon in many ways. It has been assumed for this study that the manpower necessary to perform the required tasks will be

available because replacement personnel can be easily provided from the relatively unskilled labor force. However, there will be many problems in supplying necessary equipment and materials and in traversing the local roads and streets.

In an earlier section of this report the damage to equipment was briefly discussed. Because special stockpiles of replacement parts and equipment are not contemplated to be available, it is assumed that replacement vehicles and parts will be provided from other sources. These sources might be industries located outside of the area of moderate to severe damage. Obviously, communications will be damaged which will create serious problems in tapping these "outside" sources for replacements. Further complicating the supply problem, particularly for vehicles, is the probability that some of the trucks normally used for sanitation operations will be diverted to other uses.

A general failure of the electrical power supply will probably occur postattack and this failure will seriously hinder supplying fuel to vehicles because most of the fuel storage in the Study Area must be pumped from underground tanks.

Studies[1] have shown that a supply of insecticides and poisons can be depended on to be available postattack due to adequate inventories that presently exist. Again, untrained personnel must be used to administer these items because of the emergency nature of the situation.

ven if all the supply requirements for personnel, equipment, and material could be met postattack, the problem of movement over road. blocked with debris, damaged bridges, etc. will significantly reduce the efficiency level of the operations. It is conservatively estimated that approximately 30 percent of the trees and power poles (within a radius of about 10 miles of the blast center) will be knocked down.[2] Based on this estimate, it can be surmised that about one half of the Study Area will have debris in the streets and roads that will impede vehicular traffic. Until this debris can be cleared, postattack organic waste collection operations, for that portion of the area, will be curtailed.

The lack of radio controlled vehicles and the probable loss of much of the normal telephone service due to the weapon's effects will hamper the

administration and coordination of the sanitation logistics postattack. Minimum communications will make it difficult to request mutual aid from "outside" sources, and should this aid be sent without specific request, then the lack of proper communications will limit its effectiveness.

Postattack sanitation procedures, as dictated by the weapon effects and disease problems, set the logistical requirements. Some preattack effort should be given in the planning for communications and stockpiles of equipment and material which will become critically necessary postattack.

POSTATTACK SANITATION PROBLEMS

The magnitudes of the various postattack sanitation problems in the Study Area are functions of numerous factors, many of which must be determined by assumptions based on experience, previous study(1), and intensive data collection in the San Jose metropolitan area. The problems can generally be catagorized in the following manner: (1) solid organic wastes; and (2) disease vector and host development. The type and degree of damage to the environment, discussed earlier, will dictate, to a large degree, the magnitudes of these problems.

In areas of blast damage rubble will block many streets in varying degrees; garbage collection will be disrupted; produce in canneries will subject to putrescence; livestock will be destroyed; and water from broken fire hydrants will be ponded. Because the Study Area could experience the emergency conditions in the summer, various postattack sanitation problems would be experienced to a maximum degree. The canneries would be processing the fruits and vegetables that are harvested in the summer. There would be optimum weather conditions for fly, mosquito, and rodent reproduction.

If the postattack sanitation operations can be immediately effective, the problems can be eliminated in a relatively short time and reduced to a level which was normal preattack.

This study assumes there will be no nightsoil to collect because the population will rapidly emerge from fallout shelters quite quickly when it has been established there is no hazard from fallout gamma radiation. Also, it is further assumed that the basic sewerage and water supply systems are

intact after the blast and therefore, human wastes can be handled in the normal manner.

Organic Wastes

This study focuses on organic waste management problems in the two week period immediately following the attack because it will be during this interval when the most critical problems will arise. There will be more wastes to handle with less capability and therefore the problems will become significantly more difficult to cope with during this period than in any other period either before or after.

The solid organic wastes that will exist early postattack may be classified as follows: (1) wastes which continue to be produced daily by the surviving population; (2) wastes which have accumulated and are waiting for collection and disposal at the time of the attack; and (3) materials which have been changed from useable organic material into wastes because of the effects of the weapon.

The total production of household refuse postattack will be reduced from preattack levels because of a reduction in the contributing population and because the rubbish normally originating in households from lawn clippings, etc. will no longer be created at the preattack rate. From previous study(1) the rubbish portion of household refuse is approximately 80 percent of the total combined rubbish and garbage which makes up household refuse. It is assumed that the postattack household refuse production will be only 20 percent of the preattack level, considering the reductions caused by a lower population and a lower rate of rubbish production. Admittedly, this estimate of 20 percent is approximate, but it is of the proper order of magnitude to justify using it in the overall assessment of the problem.

It is doubtful in the early postattack period that a significant volume of normal commercial or industrial solid organic wastes will be produced. In the probable environment that will prevail in the first two weeks following the attack, normal business activities of this nature will not exist due to building and equipment damage, lack of a labor force, and the more urgent needs of reestablishing order to a chaotic environment. Therefore, for the purposes of this study, it is assumed that commercial enterprises and industry in general will not produce wastes of a solid organic nature.

It is estimated that approximately 20 percent of the household, commercial and industrial, and special cannery wastes, which have accumulated up to the time of the attack, will be available for pick-up and disposal. The balance will probably be scattered by the blast. Assuming that the household refuse is collected once each week, there would be 20 percent of three day's waste production that would require collection immediately postattack, estimated to be approximately 1,880 cubic yards. Commercial or industrial wastes are collected more frequently and therefore it is assumed that 20 percent of two day's accumulation (620 cubic yards) would be required to be collected immediately. Similarly, it is assumed that 20 percent of one day's accumulation of the cannery wastes (600 cubic yards) would need immediate collection.

It is probable that the most significant amount of solid organic waste that requires collection will be that which is created as a result of the weapon effects damaging perishable and non-perishable foods at food processing and distribution centers and in the households. As described earlier, the Study Area has a relatively high concentration of canneries and frozen food processing plants. Table VII presents data on crop and livestock production, for selected items, and indicates the magnitude of the agricultural activities in the Study Area.

TABLE VII

STUDY AREA AGRICULTURAL ACTIVITIES

Item	Quantity
Cattle	5,000 head maintained annually
Chickens	90,000 birds maintained annually
Fruit	150,000 tons produced annually
Vegetables	230,000 tons produced annually
Grain	3,000 tons produced annually

During the summer harvest season (which extends from 1 June through 30 October), the canneries and frozen food processing plants receive and store raw fruits and vegetables for future introduction into the various process lines. In the Study Area, approximately 63,000 cubic yards of raw

fruits and vegetables are in storage, waiting for processing, at any one time. Depending on the items involved, this storage is in the open, in warehouses, or in refrigerated enclosures. At the time of the attack it is assumed that the fruits and vegetables which are warehoused will become exposed to the natural elements due to structural damage to the warehouses and a probable loss of electrical power. The material normally left in the open would, of course, be already exposed. For this material to be left unused and unprotected for one week will invite putrification and a resulting fly problem. Therefore, it is concluded that the aforementioned 63,000 cubic yards of raw fruits and vegetables will need to be collected by the end of the first week following the attack.

The data in Table VIII are presented to provide a summary of the solid organic waste production quantities which will be used in subsequent sections of this study where an evaluation of the effectiveness of the postattack sanitation operations is made.

TABLE VIII

POSTATTACK SOLID ORGANIC WASTE

Waste Classification	First Week Postattack Collection Requirements (cubic yards)
Three Days Household Refuse	
(3 days x 20% x 3,140 cu yd/day)	1,890
Accumulated Wastes	
Household Refuse	1,890
Commercial and Industrial	620
Canneries and Frozen Food Plants	600
Wastes Produced by Weapon Effects	
Canneries	59,600
Frozen Food Plants	3,900
TOTAL	68,500

In addition to the solid organic wastes just discussed, there is a very significant amount of both perishable and non-perishable foods in storage in food markets, produce markets, and in households. This food will also suffer damage and eventual putrification for the same reasons that affect the raw materials in storage at the canneries. However, as will be discussed later, data on this is not essential to the final assessment of the effectiveness of the postattack sanitation operations. For this reason data was not collected for these wastes. Also, there will probably be a significant number of livestock and poultry killed as a result of the weapon detonation. These dead animal carcasses will again add to the total solid organic waste that must be collected and disposed of in order to maximize postattack sanitary conditions. However, these animal carcasses will create a non-vectorial blowfly problem which is mainly a nuisance to the population

Mosquito, Fly, and Rodent Control

The populations of flies and mosquitoes will probably increase over preattack levels because of the damage conditions postattack. Also, both will be a more intense problem in the summer months because of climatic conditions conducive to the breeding of these vectors.

The relative amount of putrifying organic material left uncollected will be a measure of the relative fly population increase to be expected postattack. Similarly, the relative increase in standing ponds of water will be a measure of the probable increase in the mosquito population. Because of warm daytime temperatures and relatively cool nights, the house fly (Musca Domestica) cycle from egg to adult will be about 10 to 12 days, with adult flies living about a month. The available putrescible food will provide breeding media for these flies.

Although the rat population will not increase significantly because of postattack damage, the probability that the human population will be living in improvised shelters among the rubble and debris from the blast will bring them in closer contact and therefore increase the intensity of

the rodent problem. It is estimated that 15 percent of the households in the area will require ectoparisite and rodent flea control measures to maintain the preattack disease incidence levels for Murine Typhus, Leptospirosis, and Plague.

POSTATTACK DISEASE HAZARDS

When considering the four catagories of diseases (enteric, rodent borne, mosquito borne, and miscellaneous) that probably will occur postattack, it is assumed that the enteric diseases will affect the largest proportion of the population. However, because it is also assumed that there will be no nightsoil from shelters, the significance of the enteric diseases in this study is less than for other postattack environments which might have a nightsoil collection and disposal problem. An indication of the relative endemicity of each of the 14 diseases considered herein is presented in Table IX.

Enteric Diseases

Without effective postattack sanitation operations, the enteric diseases (Shigellosis, Salmonellosis, Infectious Hepatitis, Typhoid, and Amoebiasis) could become a serious problem. Shigellosis is of the highest concern because of the naturally large reservoir in the population. In fact, Shigellosis would be more serious than any of the other enteric infections and many of the more exotic diseases if there were a loss of potable water supplies and/or sewage systems. Infectious Hepatitis and Salmonellosis are also of concern and could seriously damage the surviving population if care is not exercised in maintaining sanitary water supplies in the postattack period. Typhoid and Amoebiasis could also become serious problems if proper sanitation measures were not maintained.

Rodent Borne Diseases

Rats cause a variety of problems including food damage, Leptospirosis, Murine Typhus, and Plague -- all in varying degrees. However, because the population growth rate of rats is less than that for insects, the control measures affecting rats may lag behind those for the insect vectors.

Leptospirosis has a low endemicity factor primarily because of the extremely low incidence of this disease in humans during peacetime. Murine Typhus will not create a large postattack problem, again because the dis-

ease is not normally prevalent in the Study Area. However, because Plague has repeatedly been found in small rodents in the Study Area, it could become a very serious disease problem as indicated by its endemicity factor shown in Table IX.

TABLE IX

DISEASE ENDEMICITY FACTORS (1) FOR DISEASES OF THE ENVIRONMENT, SANTA CLARA VALLEY, AUGUST 1965

Diseases	* A x B X C x D	=	Value
Enteric Diseases			
Shigellosis	3 x 2 x 1 x 5	=	30
Salmonellosis	3 x 2 x 1 x 5	=	30
Infectious Hepatitis	3 x 2 x 1 x 5	=	30
Typhoid	1 x 2 x [illegible] x 5	=	10
Amoebiasis	2 x 2 x 1 x 5	=	20
Encephalitides - Mosquito Borne	1 x 2 x 1 x 3	=	6
Rabies (Animals)	1 x 2 x 1 x 5	=	10
" (Humans)	1 x 2 x 1 x 3	=	6
Leptospirosis	1 x 2 x 1 x 1	=	2
Murine Typhus	1 x 2 x 1 x 1	=	2
Plague (Animals)	3 x 2 x 1 x 5	=	30
" (Humans)	1 x 2 x 1 x 3	=	6
Rocky Mountain Spotted Fever	1 x 2 x 1 x 1	=	2
Dengue Fever	0 x 2 x 1 x 1	=	0
Malaria	1 x 2 x 1 x 1	=	2
Yellow Fever	0 x 2 x 1 x 1	=	0

* See page 5[illegible] of Reference 1 for a detailed explanation of the Disease Endemicity Factor.

Mosquito Borne Diseases

Encephalitis is the most serious of the mosquito borne diseases to consider as the others (Dengue, Yellow Fever, and Malaria) have not occurred recently in the Study Area. However, because (1) infected birds

will probably be present, (2) the temperature is favorable, and (3) the mosquito vector of encephalitis exists in the Study Area, the possibility of this disease should be considered a basic reason for implementing effective postattack mosquito control.

Miscellaneous Diseases

Because a Rabies reservoir exists in wild animals in the Study Area, this disease should be considered significant when executing postattack sanitation activities. The endemicity factor for Rocky Mountain Spotted Fever is very low, although the tick vector is found in the area. The reservoir of wild animals carrying the tick is rapidly disappearing due to rapid urban expansion.

POSTATTACK SANITATION PROCEDURES

The purpose of this section is to define the logistical requirements and timing sequence for postattack sanitation operations required to maintain levels of disease incidence at prevailing preattack levels. With the effective application of the suggested countermeasures, disease epidemics can be prevented and localized outbreaks confined to small segments of the surviving population, with little overall effect on the Study Area recovery.

The postattack sanitation procedures can be catagorized as follows: (1) solid waste collection and disposal; (2) measures for control of houseflies; (3) rodent control measures; and (4) counter controls for mosquitoes. The following stated supply requirements are based on the assumed postattack environment in the Study Area and the further assumption that no stockpiled materials are available. Where deficiencies exist, they should be augmented from mutual aid sources.

An effective plan and adequate personnel to administer it are required in order to attain an effective level of use of the stated requirements which follow. The comprehensive and complex nature of the organizational problem becomes apparent when one considers that such operations would include the efforts of local health departments, public works departments, mosquito abatement districts, private exterminator companies, state and federal agencies, and the individual householders. A knowledgeable individual, supported by a competent staff, should be given the responsibility and authority to direct the postattack sanitation operations.

The most important single operation is that of collecting and disposing of the solid organic wastes in the Study Area. Next in priority is the control of houseflies, along with mosquito control. Countermeasures against rodents are the fourth most important of these vital procedures.

This study assumes that organic wastes left uncollected for seven days will encourage an increase in the fly population. Therefore, organic waste collection and disposal should be initiated as soon as personnel and equipment can be assembled and mobilized, which will probably be on the second or third day following the attack. Table X gives information regarding the relative timing of the four catagories of postattack sanitation operations.

TABLE X

TIMING SEQUENCE FOR POSTATTACK SANITATION PROCEDURES

Timing	Organic Waste Collection	Fly Control	Rodent Control	Mosquito Control
First Week	Procede at Intensive Rate	Begin Adulticiding	---	---
Second Through Fourth Weeks	Continue at Rate Which Declines as the Intensity of the Problem Decreases	Continue at a Reduced Rate	Place Poisons and Traps. Initiate Dog Extermination and Ectoparisite Control Measures	Initiate Larvaciding
Second Through Twelfth Month	Return to Normal Operations	Return to Normal Operations	Return to Normal Operations	Return to Normal Operations

Solid Waste Collection and Disposal

The data in Table VIII show the quantities of organic waste material that must be collected in the first week following the attack. Waste which

can be collected should be picked up, but that which is combined with relatively large proportions of debris and rubble could also be burned to abate a health hazard. The assumption has been made that 68,500 cubic yards of organic wastes (shown in Table VIII) can be collected and therefore the quantitative requirements which follow assume that it should all be collected and disposed of in the seven days immediately following the attack.

Information presented in Chapter II indicates that a collection vehicle is capable of collecting and hauling to the disposal site approximately 180 cubic yards in 44 hours or about 4.1 cubic yards per hour. Assuming that the postattack collection and disposal activities would operate 16 hours per day for the first seven days (112 hours), the required gross collection rate would be 68,500 CY in 112 hours, or 612 cubic yards per hour. This rate of collection and disposal would require about 150 collection vehicles. Ideally, the numbers of the various types of vehicles would be in the same proportions as they were preattack.

The fuel requirements for collecting the wastes postattack will be in the same proportion as the amount of postattack wastes are to those preattack, that is (68,500 CY/55,000 CY) X (2,500 + 2,100) gal = 5,730 gallons.

The disposal site equipment normally operates 48 hours per week and is capable of handling the 55,000 CY of waste collected every week in the preattack period. From the data in Chapter II it can be seen that 25 tractors x 48 hrs (1,200 tractor-hrs) can handle 55,000 CY of waste. On a unit basis this is one tractor-hour per 46 CY. Again assuming a 112 hour work week and 68,500 CY of wastes to be handled, the postattack requirement at the disposal sites is about 13 tractors.

The draglines in the Study Area are used only for work in areas where water and mud preclude the use of tractors. For the purpose of this study it is assumed that sufficient areas will be dry during the first week postattack to eliminate the necessity of using any draglines.

On the basis of the above analysis, Table XI shows a summary of equipment and manpower required to maintain an effective postattack organic waste collection and disposal program.

TABLE XI

EQUIPMENT AND SUPPLIES FOR SOLID ORGANIC WASTE COLLECTION AND DISPOSAL

Equipment		Units		
Automatic Packer Trucks		114		
Open Trucks and Others		36		
Tractors		13		
Draglines		Zero		
	TOTAL	163		
Fuel			Gallons	
Collection Vehicles			5,700	
Tractors			2,600	
	TOTAL		8,300	
Personnel				Number
Collection Vehicles				600
Tractors				26
Supervisors				16
	TOTAL			642

Measures for Control of Houseflies, Rodents, and Mosquitoes

Tactical measures for the control of adult houseflies should be instituted in those parts of the blast damage areas where organic wastes have not been removed within a week of the blast. Initial treatment should be by airplane sprays; as rubble is removed from the streets, ground treatment for adult fly control can be instituted. The requirements for adult fly control are given in Table XII.

Due to tactical measures for control of adult filth flies, in treated recovery and habited areas, mosquitoes such as culex tarsalis will be controlled in these areas by these same measures sufficiently to greatly reduce the possibilities of development of mosquito borne encephalitis.

TABLE XII

ADULT FLY CONTROL

Airplane Applied Adulticide (4)

Equipment	Materials	Manpower
1 - spray plane, spray equipment calibrated to disperse 2 gallons of 0.2 lb/gallon insecticide per acre.[a]	28 - 55 gallon drums of 25% E.C. Diazinon diluted with enough water to make 0.2 lb per gallon.	1 - pilot 2 - radio control ground spotters. (flagmen)
1 - hand operated fuel drum pump.	600 gallons - 100 octane airplane gasoline.	

Ground Applied Adulticide

Equipment	Materials	Manpower
2 - two ton flatbed trucks.	200 gallons gasoline	2 - Mixer men (8 hr shifts)
2 - Mist sprayers, vehicle-mounted with 300 gallon tank, 10 gallon/ minute capacity.	28 - 55 gallon drums[b] of 25% E.C. Diazinon diluted 11 gallons to 34 gallons water.	1 - Supervisor 4 - Spraymen 2 - Mixer men (2 shifts)

(a) The required flow rate can be computed by the following formula:

$$F = \frac{SWD}{495}$$

F = required flow rate in gallons (US) per minute

S = speed of plane in miles per hour

W = effective swath width of spray deposit, determined experimentally for each type of equipment (70 to 150 feet for the Stearman)

D = dosage rate in gallons of spray per acre

(b) Total of 56 (55 gallon drums for one airplane spray followed by one complete ground spray)

Due to the presence of wild animal rabies, destruction of overt wild animals and wild dog packs should be instituted as soon as these packs

become evident, or single dogs remain unclaimed after a week. See Table XIII for needed operations.

TABLE XIII

EQUIPMENT AND MATERIALS FOR RABIES CONTROL

2 - Twelve gauge shotguns.
1,000 - Shotgun shells.
2 - Men to work 14 days killing stray dogs and overt wild animals.

Because of "hard core" plague endemicity in small field rodents in nearby San Mateo County, and a history (1945) of wide-spread plague in field rodents in Santa Clara Valley, ectoparasite control in the blast areas adjoining farming and uncultivated areas should be instituted. This should be done within two weeks of the attack to prevent infiltration from wild rodents into the domestic rodent population which is low to moderate in numbers. Ectoparasite control should be on residential and commercial premises, followed by rodent control measures. Table XIV presents data on the requirements for the control of the domestic rodents as well as requirements for ectoparisite control.

TABLE XIV

DOMESTIC RODENT CONTROL NEEDS

RODENTS

Materials

Anti-coagulant poison-bait -- Loose	5,400 lbs.
Anti-coagulant 1 oz. concentrate-packets	6,000 packets
1080 Concentrate	120 lbs.
Zinc Phosphide Concentrate	120 lbs.
Calcium Cyanide Dust	180 lbs.
Snap Traps	600
Bait Boxes	450
Calcium Cyanide Pumps	12

Manpower

Field Supervision	2
Control Men	24

(TABLE XIV, Continued)

RODENTS	
Vehicles	
1/4 ton trucks	26
Fuel	26,000 gallons
ECTOPARISITE - RODENT FLEA CONTROL	
Materials	
5% or 10% DDT Dust	32,000 lbs.
Rotary Hand Dusters	45
Manpower	
Field Supervision	2
Control Men	20
Vehicles	
1/4 ton trucks	20
F· el	4,000 gallons

EVALUATION OF CAPACITY TO EFFECT CONTROL MEASURES

An evaluation of the relative effectiveness of the postattack sanitation procedures must be based on a comparison of the numbers of men and the quantities of materials and equipment existing postattack to the same catagories necessary to maintain disease incidence at preattack levels. Table XV makes this comparison for the postattack organic waste collection and disposal operations.

As shown in Table XV the primary deficiency in the collection and disposal operation is the lack of sufficient collection vehicles. Fuel for the operation of the equipment will be another control (should there be a power loss the fuel will not be available due to the dependence upon electric power for pumping). As stated earlier, it is assumed that personnel required to perform the work involved can be obtained from the surviving population and therefore personnel requirements can be met. Regarding organic waste collection in the Study Area, it is concluded that due to a shortage of collection vehicles and a probable lack of fuel,

effectiveness will be limited to about 70 percent of the desired minimum capability. Fly control will then become much more significant in maintaining proper postattack sanitation; however, because the logistical requirements for fly, mosquito, and rodent control are relatively small, it is assumed that the Study Area resources can meet the basic requirements. The effectiveness of these countermeasures will depend heavily on the proper administration and coordination of procedures. It is in this area of management that an apparent deficiency exists postattack. Until this deficiency can be corrected, the level of effectiveness of sanitation operations and procedures will be below that required.

TABLE XV

EFFECTIVENESS OF POSTATTACK SOLID ORGANIC WASTE COLLECTION AND DISPOSAL OPERATIONS

Item	Required Quantity	Available Quantity	Percent of Requirements Satisfied
Equipment			
Automatic Packer Trucks	114	60	53%
Open Trucks and Others	36	46	128%
Subtotal	150	106	70%
Tractors	13	13	100%
Draglines	Zero	Zero	100%
Fuel			
Collection Vehicles	5,700 gal	Min 7,500 gal[a]	132%[a]
Tractors	2,600 gal	Min 2,600 gal	100%
Personnel			
Collection Vehicles	600	600	100%
Tractors	26	26	100%
Supervisors	16	16	100%

(a) In below ground storage tanks requiring electric pump operation before fuel can be obtained. This does not include the minimum amount of fuel in the collection vehicle's fuel tanks.

Although the assessment of postattack sanitation procedures, as measured in terms of equipment and supplies, indicates a level of effectiveness lower than desired, the overall effect on the health of the surviving population will probably not be seriously detrimental to the postattack recovery of the Study Area.

CHAPTER IV

SEDIMENTARY EFFECTS OF FALLOUT IN DRAINAGE SYSTEMS

This chapter deals with the sedimentary effects of the sand-like fallout particles that could be washed into a drainage system in a postattack situation.

The "afterwinds" produced in the immediate vicinity of a nuclear weapon burst can cause varying amounts of dirt and debris (depending upon height of burst, size of weapon, and the nature of the terrain below) to be sucked up from the earth's surface to form a cloud of dirt and other debris.

As the violent disturbance due to the explosion subsides, the contaminated debris gradually falls back to earth. The material dropping back to the earth's surface is referred to as fallout. The particulate matter which reaches the earth within 24 hours after a nuclear explosion is arbitrarily called early fallout.[2]

The effects of this sand-like sediment load on a drainage system can vary from little or no effect to complete clogging of the system, thus rendering it useless. It is important to determine these effects because the overall postattack recovery of an area could be seriously curtailed if the drainage system ceased to function because of clogging with fallout material.

The question of the possible sedimentary effects of fallout on a drainage system will be examined under the following conditions: (1) the washing of fallout on the surface, by natural precipitation or wet decontamination procedures, to the point of inlet into a drainage system; (2) the transport of the fallout through the inlet structure; and (3) the transport of fallout in the systems of conduits, etc., which make up the drainage system. The manner in which the fallout particles are transported to the

inlet structures is extremely important and the following analysis will develop some guidelines regarding the use of wet decontamination procedures that will enhance the ability of the drainage system to handle the imposed sediment load.

Specifically, the sedimentary effects of the fallout may cause stoppages, flooding, or simply reduce the hydraulic capacity of various components of the drainage system such as catch basins, connector pipes, laterals, mains, trunks, outfalls, channels, pumping facilities, and discharge structures. This study considers the primary components (catch basins, connector pipes, and the underground piping system) and develops methods of analysis to obtain an indication of the sedimentary effects on these components.

Because the fallout from a nuclear weapon detonation is essentially sand, dirt, and debris, the basic question is the manner and quantity of this material that can be carried by the various drainage components, versus the loads of the fallout imposed on said components. If the ability to transport is less than the rate at which the sediment is applied to a particular section of the system, it can be concluded that some of the sediment will deposit in that section. Although very little information is available regarding sediment transport in pipes, much work on this subject has been done as it relates to streams and irrigation canals. This previous work considers the movement of the sediment to essentially consist of a bed of material being translated downstream through the rolling, sliding, and skipping of the individual particles. This study takes the approach that the transport of fallout is similar to the bed-load movement as described, and makes application of this principle to specific problems.

There is a distinction between "bed load" and "suspended load". The bed load consists of the particles that are transported in the manner described above. The suspended load is made up of particles that remain in suspension and are thus transported throughout the length of the conduit. The "total" sediment load is thus made up of the "suspended" plus "bed-load" portions. However, the literature[5 and 6] indicates that the sediment transport formulas commonly used usually do not make this distinction. It is usually assumed that the bed-load formulas can be used to determine the total load because the empirical data collected thus far do not indicate the necessity for any further refinement.

Usually the bed-load formulas consider the difference between the actual shear stress (between the particles and water) and the "critical" shear stress (that just causes movement of the particles). The difference between these stresses is a measure of the fluid's drag force on the particles. Einstein[7] has introduced the statistical nature of the bed-load movement into his well known equation for bed-load transport. His equation is based on physical reasoning and dimensional considerations.

The use of any of the bed-load transport formulas requires the assumption that the water causing the sediment to move is flowing over a bed of sand. Other assumptions are inherent in the development of the various transport equations; however, further development is beyond the scope of this report. In summary, the quantity of sediment moved is affected by many variables including: (1) particle size, density, and shape; (2) depth, width, and velocity of flow; (3) slope of the energy gradient; and (4) the temperature and turbulence of the water.

For the purposes of this study it is assumed that the drainage system will be intact. The sedimentary effects of fallout that may enter drainage systems, because of natural rainfall and wet decontamination operations, will be examined and discussed.

BASIC PARAMETERS OF ANALYSIS

As previously mentioned, in order to use any of the existing bed-load equations it is necessary to assume that a bed of sand exists. It is also necessary to make a further simplifying assumption regarding the gradation of the fallout. Although the fallout will initially consist of various grain diameters, generally between 0.075 mm (millimeter) and 0.75 mm, it is assumed that the wind will segregate the particles before they reach the ground.[35] Therefore a narrow size fraction is assumed to exist at any one location and the fallout can therefore be described by a mean particle diameter. The following particle diameters have been chosen as representative examples for use in this study: 0.00025 ft (approximately 0.075 mm); 0.00065 ft (approximately 0.20 mm); and 0.0025 ft (approximately 0.75 mm). This analysis assumes that the least movable (usually the coarse) particles will govern the limit of transport and therefore, it is reasonable to concentrate on the largest particles (diameter of 0.0025 ft).

Additional assumptions regarding characteristics of the particles and the density of the fallout deposited on various surfaces are as follows:

(1) Compacted Unit Weight of Particles, γ_s, 115 lb/ft^3

(2) Specific Gravity of Particles, S_s, 2.6

(3) Surface Mass Loading, J, 0.11 lb/ft^2 (50 gm/sq ft)

Appendix II includes a complete list of symbols and units for this section.

One of the most accepted and generally used formulas for determining flow velocity, in both pipes and open channels, is the Manning Formula which is usually written in the following form:

$$V = \frac{1.486}{n} R^{2/3} S^{\frac{1}{2}} \quad \left\{ \begin{array}{l} \text{See Appendix II for} \\ \text{symbol definitions} \end{array} \right.$$

Of course there are many other forms, such as those in Reference 8, for the Manning Formula which can be used more conveniently in various situations. Figure 2 is included here to aid in solving the Manning Formula for pipe flow.

As mentioned above, this study assumes that there is no debris entering the drainage system at the time determination is made of the sedimentary effects of the fallout on the system. This assumption is made to simplify the analysis; however, under actual conditions it is most probable that debris will enter the system (particularly during heavy rainfall), and this will certainly increase the probability of sediment deposition and eventual clogging. Experience has shown that sand-like particles, in themselves, seldom clog drainage systems during storms. Usually debris will become jammed in the system which causes a sudden dissipation of energy, with the result being an increase in the rate of sediment deposition.

Because fallout can be introduced into a drainage system through the use of wet decontamination procedures, this study assumes the adequate availability of a water supply for this purpose.

If the sediment transport rate of any given component of a drainage system is less than the sediment supply rate, it is assumed that sediment

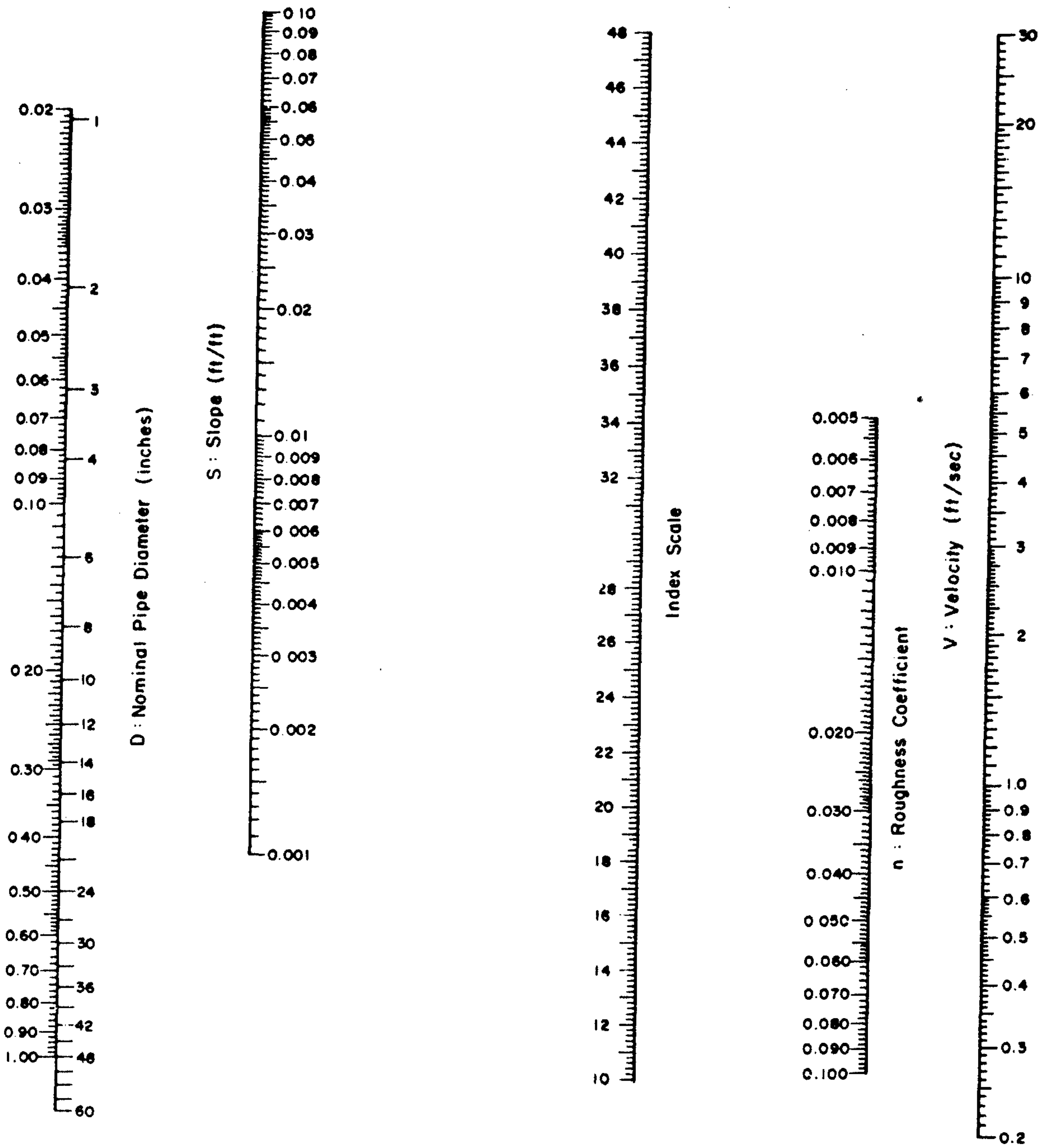


Figure 2.— MANNINGS FORMULA FOR CIRCULAR PIPES FLOWING FULL (9)

will build up. If the transport rate of a section exceeds the supply rate, then it is assumed that that segment of the system will be scoured clean, if the flow rate of the incoming water is maintained for a sufficient period of time. When analyzing a segment of a drainage system it is assumed that the supply rate is equal to the transport rate immediately upstream.

METHOD OF ANALYSIS

The analysis of the sedimentary effects of fallout begins with a study of the manner in which the fallout is transported to the drainage system inlet point (either through the process of wet decontamination procedures or as a result of storm water runoff). The next step will be to examine the mechanics of sediment transport in catch basins. The third phase of the analysis will be the study of the transport of the sediment in connector pipes, street mains, outfalls, and open channels.

H. A. Einstein[7] has developed equations which can be used to determine the rate of sediment transport. This approach has been applied to develop data on transport rates for drains ranging in size from a 0.5 foot diameter pipe to a 20 by 10 foot channel for various rates of flow, slopes, and mean particle diameters. The results of this work are presented in Figures 3, 4, and 5.

The bed-load or transport rate, in dry weight per unit of time and unit of width can be calculated from the following equations by Einstein:

$$\Phi = \frac{q_s}{\gamma_s \, g^{1/2} \, d_{35}^{3/2}} \sqrt{\frac{\gamma}{\gamma_s - \gamma}} \quad \text{where } \Phi \text{ is}$$

$$\text{a function of } \psi \text{, and } \psi = \left(\frac{\gamma_s - \gamma}{\gamma} \right) \frac{d_{35}}{S_e \, R_b}$$

{See Appendix II for symbol definitions

The basic assumption used in preparing Figures 3, 4, and 5 is that the flow of the water takes the form of a wide, shallow canal flowing over a uniform sand bed. This assumed two-dimensional analysis allows the use of the Einstein equations in the small conduits, but also imposes some restrictions on the use of the bed-load transport curves in Figures 3, 4, and 5. It was assumed, in all cases, that maximum transport took place

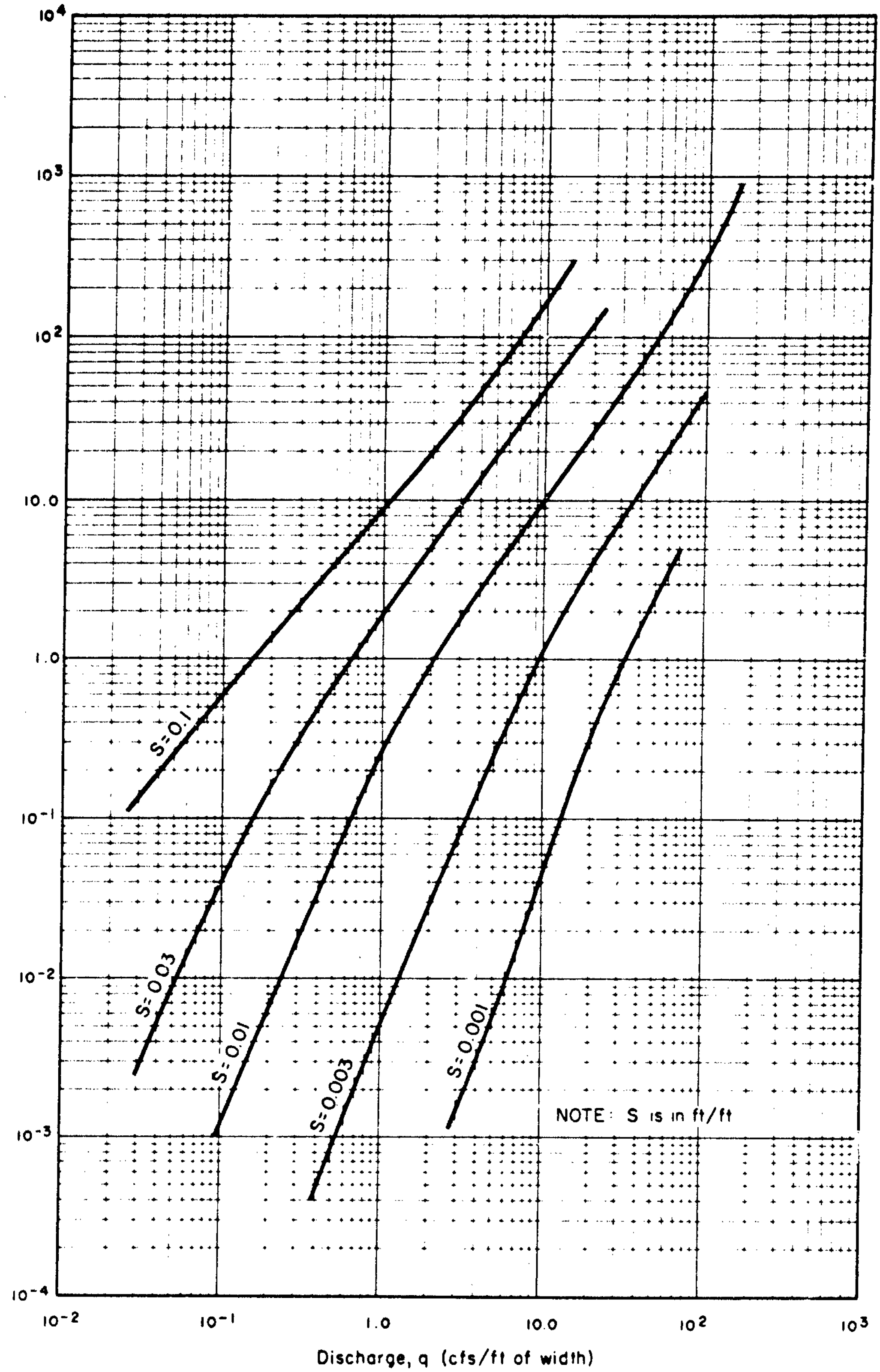


Figure 3.— SEDIMENT TRANSPORT CAPACITY - PARTICLE DIAMETER OF 0.0025 FEET

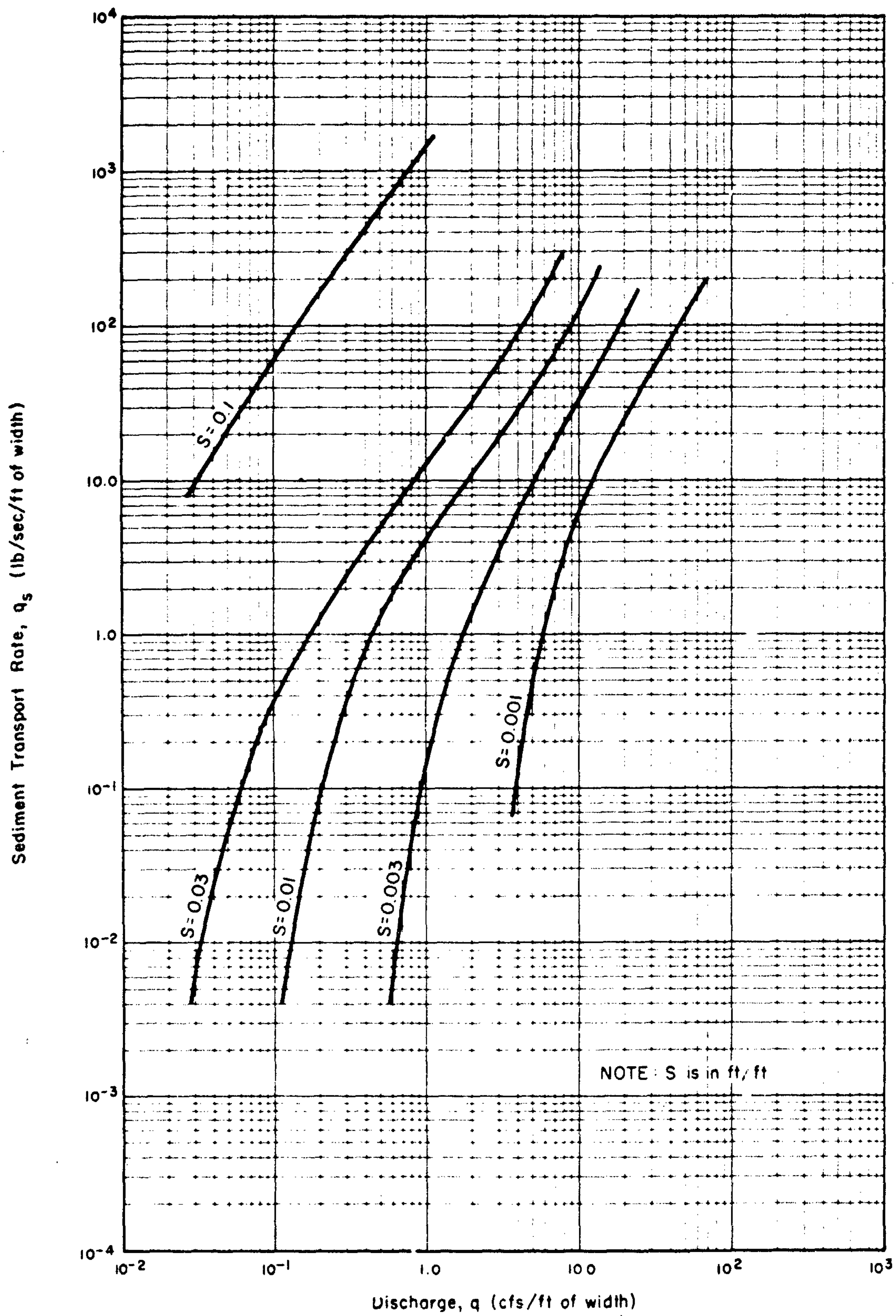


Figure 4.— SEDIMENT TRANSPORT CAPACITY - PARTICLE DIAMETER OF 0.00065 FEET

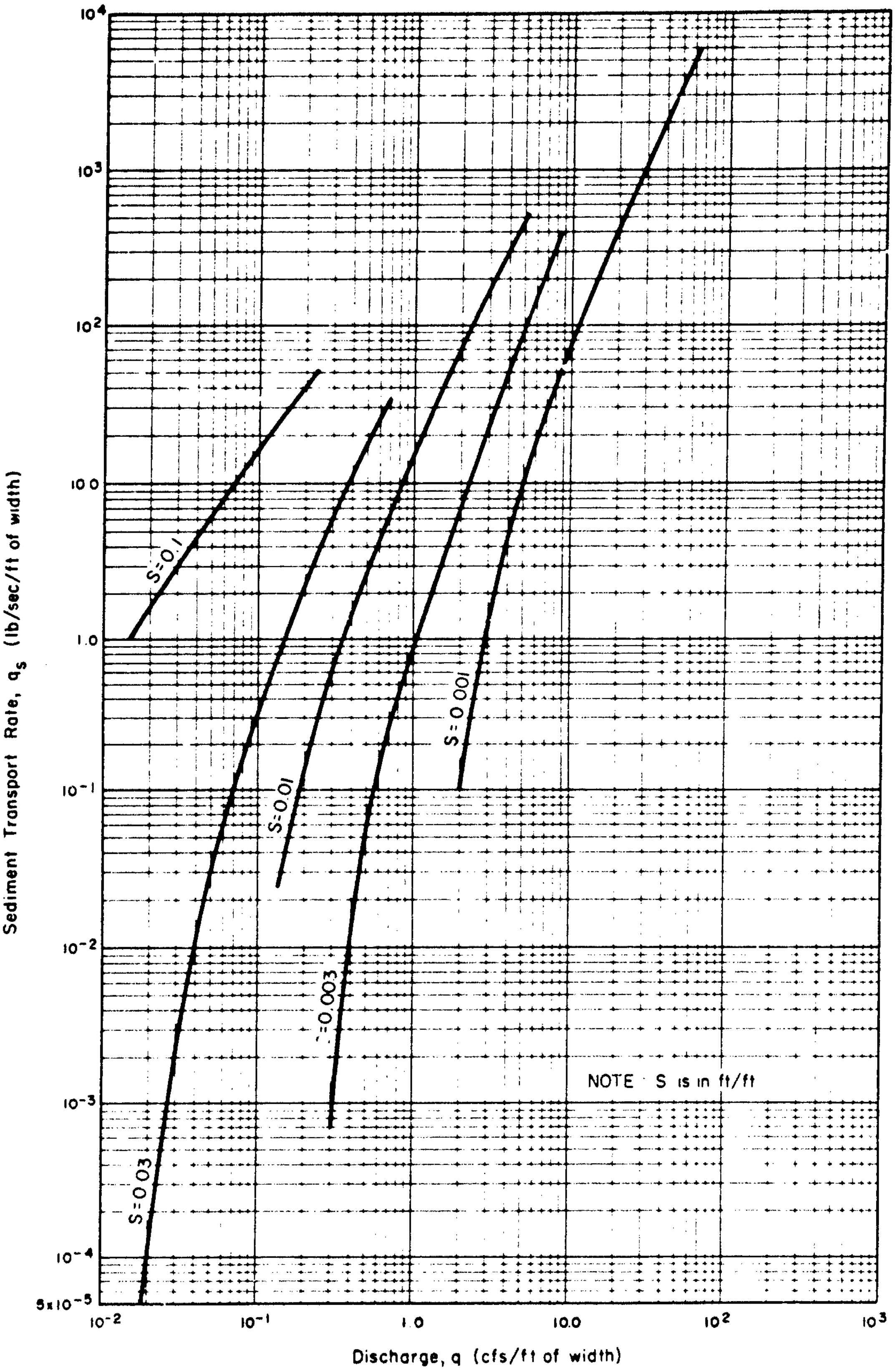


Figure 5.— SEDIMENT TRANSPORT CAPACITY - PARTICLE DIAMETER OF 0.00025 FEET

because the entire bottom of the conduit was covered with sand. In the case of pipes, the sediment bed was assumed to have filled the pipe to one-third of the pipe diameter. The flow section above this bed is assumed to be rectangular. Einstein has suggested that the side-wall friction can be neglected in pipes as long as the depth of flow above the sand bed does not exceed one-third of the pipe diameter. If the depth of flow exceeds this level, the excess flow will contribute mostly to the side-wall friction and not to the transport capacity.

The grain roughness of the bed was assumed to be equal to the representative grain size, as in any uniform bed. A correction[10] was introduced to Einstein's work to give the change in the lift coefficient on the particles at low Reynolds Numbers.

It should be noted that transport capacity data based on the above assumptions is not applicable to pipes flowing under pressure. However, as long as the flow is considered very shallow as compared to the width, the curves in Figures 3, 4, and 5 can be used for pipes and rectangular channels. For flow in gutters, or other triangular sections, it is necessary to assume a sand bed deep enough to reshape the flow cross section so that it corresponds more closely to a trapezoidal cross section with a shallow depth of flow. The essence of this limitation is to maintain a small depth to width ratio so that friction from the sides of the conduit can be neglected.

The side wall friction in drainage systems is not as important as it is in natural channels because of the relatively smooth surface. It is estimated, however, that this omission may cause a maximum error in transport capacity of as much as 100 percent, or of a factor with a possible range of one-half to two. For many engineering calculations such an uncertainty would be prohibitive. For sediment transport rates, however, which vary in their significant range over at least four cycles (see Figures 3, 4, and 5), this factor of uncertainty is relatively unimportant. A comparison of the curves in Figures 3, 4, and 5 indicates that a small error in estimating the mean particle diameter of the fallout (assuming also that the particles are all of uniform diameter) will result in much greater errors in the transport rate than 100 percent, or a factor of two.

Interpolation of the data in Figures 3, 4, and 5 is permissible, but no attempt should be made to extrapolate any values because the information thus obtained will be unreliable.

Because the depth to width ratio is limited to relatively small values in order to minimize the effects of side-wall friction, the hydraulic radius (equal to the cross sectional area of the flow divided by the wetted perimeter) can be assumed equal to the depth of flow for most cases. As an aid in making the analyses and calculations which follow, graphs representing the important hydraulic elements of the flow have been prepared and are shown in Figures 6, 7, and 8. These hydraulic elements change, particularly in the smaller pipe sizes, due to the relative changes in bed roughness created by the various particle sizes. The same limiting assumptions given for Figures 3, 4, and 5 will apply to Figures 6, 7, and 8 because they have been developed together on the basis of Einstein's Formulas.

The downstream component's maximum flow rate cannot exceed the flow rate which would cause the system to flow under pressure because the method of analysis does not cover the case of pressure flows. In the case of a single line of drainage this is relatively simple to determine. However, in a complex system which receives contributions at various points along its main route, the times of concentration of the various contributing flows become important.

Transport of Fallout to Drainage System Inlet

In the preceding paragraphs the basic tools to be used in analysis of the three stages of fallout transport have been presented. The following discussion is concerned with the mechanism of transport of fallout to the inlet of the drainage system which is the first of the three stages. It is necessary to determine this transport rate as it will become the supply rate that the inlet structure must be able to handle if it is not to become clogged.

For the purpose of this study, fallout will be considered to be transported through flows created either by natural rainfall or by wet decontamination procedures. Each mode of transport has different characteristics and will affect the drainage system in different ways.

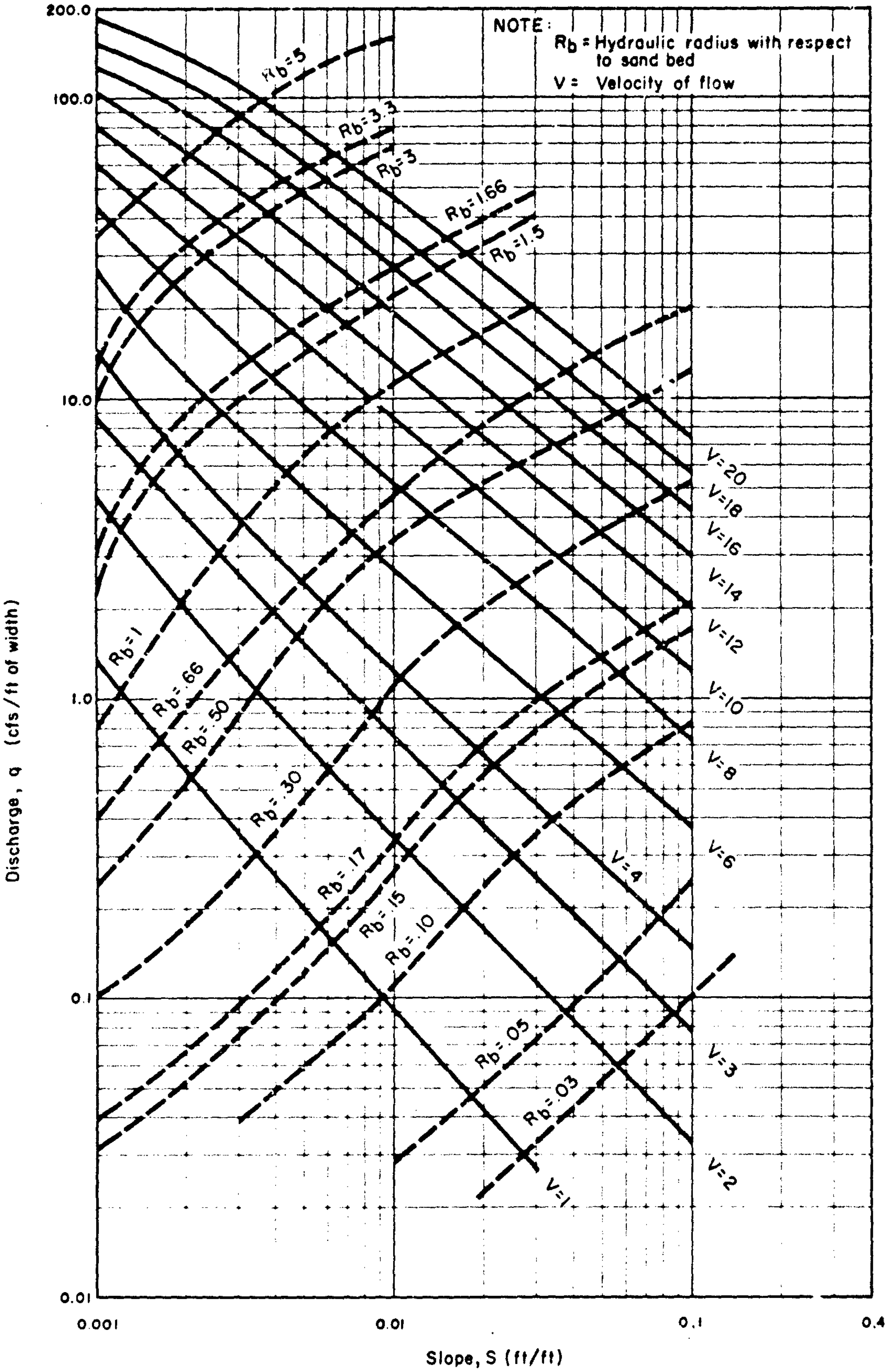
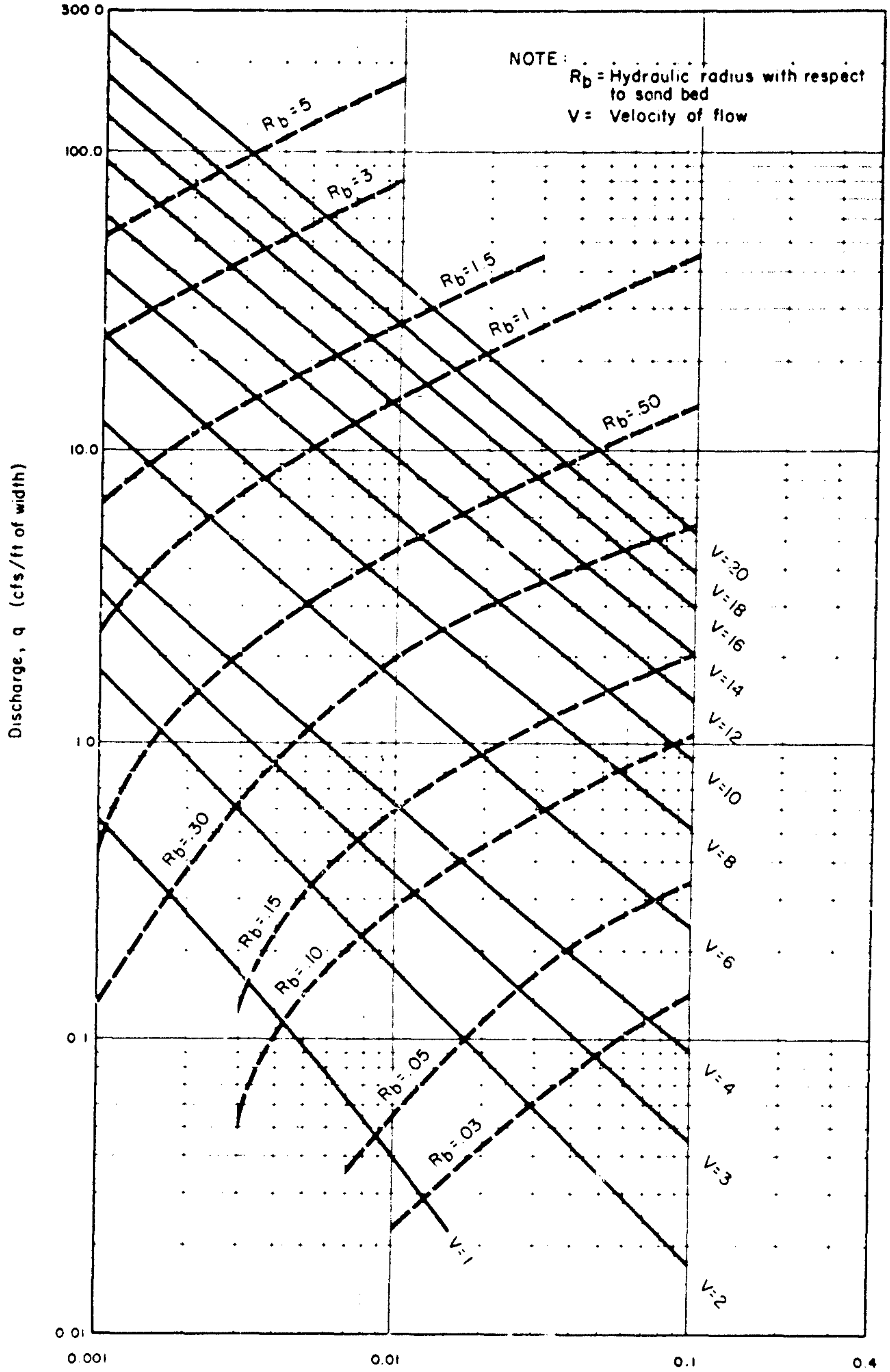


Figure 6. — FLOW CHARACTERISTIC CURVE - PARTICLE DIAMETER OF 0.0025 FEET



Slope, S (ft/ft)

Figure 7. — FLOW CHARACTERISTIC CURVE - PARTICLE DIAMETER OF 0.00065 FEET

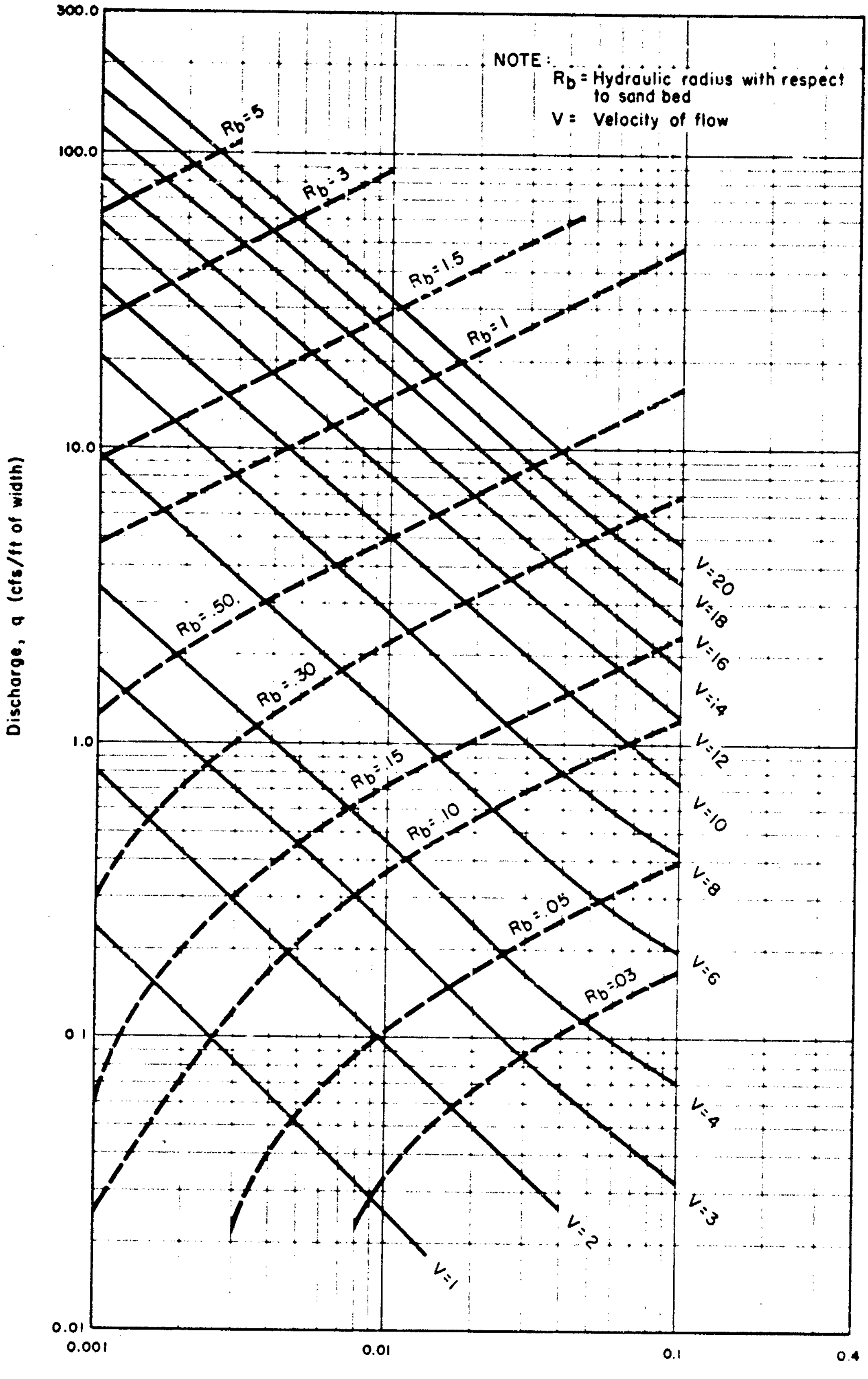


Figure 8. -- FLOW CHARACTERISTIC CURVE - PARTICLE DIAMETER OF 0.00025 FEET

Transport by Natural Rainfall

Many different kinds of surfaces exist in a drainage area. These surfaces can include impervious roofs, pervious grass covered areas, and slopes that are steep or flat. Different degrees of storage potential are created by depressions or irregularities. As these same factors directly affect the quantities of runoff, so will they also affect the amount of fallout which will be washed to a drainage system. The amount of fallout which is transported by flowing water is a direct function of the rate of flow.

Rainfall creates three basic types of fallout transport to the drain system inlet: (1) transport by the thin laminar overland flows on roofs, driveways, sidewalks, lawns, etc.; (2) transport by the deeper, more concentrated, flows in the gutter and street; and (3) transport by raindrops imparting kinetic energy to the particles.

Izzard[11] has developed empirical equations which allow the determination of the rate of flow per foot of width over developed surfaces. For example, a rainfall intensity of one inch per hour would create approximately 0.00464 cfs/ft (cubic feet per second per foot of width). By reference to Figures 3, 4, and 5 it can be shown that the transport rate of fallout by overland sheet flow, is relatively insignificant. Therefore, for the purposes of this study, fallout transport by overland flow will be considered an insignificant contribution. Rainfalls of a higher intensity can create more significant contributions, particularly when roof drains are directly connected either to street gutters or the drainage system itself.

Ellison[12][13] has shown that the energy of falling raindrops may be a very important factor in erosion. Raindrops may vary in diameter from 0.02 to 0.25 inches and have terminal velocities of from 12 to 25 feet per second. The kinetic energy from large drops, with high terminal velocities, can cause top soil to rise to a height of several feet. The above finding indicates that the affect of raindrops will assist in transporting fallout particles to locations of flows carrying significant loads of sediment. However, quantitative determination of the rate of fallout transport by this means is not attainable and thus it has not been included in this study.

The most significant mode of transport occurs when the quantities and velocities of flow reach levels obtained in streets and gutters with relatively heavy rainfalls. In order to determine these flows it is necessary to find the runoff from the drainage area and relate this to the street or gutter to obtain the hydraulic characteristics of the flow cross section. Because most inlets to drainage systems receive water from relatively smal areas, the rational formula for runoff, $Q = ciA$, can be used to determine the quantity of flow. In this formula: Q is in cfs; c is the runoff coefficient; A is the area of the contributing drainage basin in acres; and i is the rainfall intensity in inches per hour.

The determination of the runoff factor, c, requires a knowledge of th following characteristics of the drainage area: (1) the relative imperviousness of the surfaces; (2) the distribution of the rainfall on the drainage area; and (3) the relative retention created by depressions and absorption. A value of c that is generally accepted for well-built-up por tions of a city (not the most densely developed areas) is about 0.60. A similar value for asphaltic pavements is 0.90.

The rainfall intensity is dependent upon many factors such as the storm frequency and duration. The duration usually chosen for determining the rainfall intensity is equal to the "time of concentration". The time of concentration (equal to the inlet time for this discussion) is the time it takes water to travel from the most remote point in a drainage basin to the inlet. For small drainage areas contributory to a single catch basin, this time is usually less than 15 minutes, which then makes the rainfall intensity about the highest that can be usually expected for any given storm frequency.

Once the runoff has been determined for a particular inlet, it is necessary to relate this flow rate to the street and/or gutter in order to determine the hydraulic characteristics. Figure 9 has been included to aic in making these determinations.

If the flow in a street exceeds the capacity of the inlet structure or catch basin, then a portion of this flow must either be stored by overtopping the curb or it must run off into other drainage areas. The rates of flow in a street which determine the sediment supply rate to a catch basin cannot exceed the inlet capacity of such a structure. Therefore, it

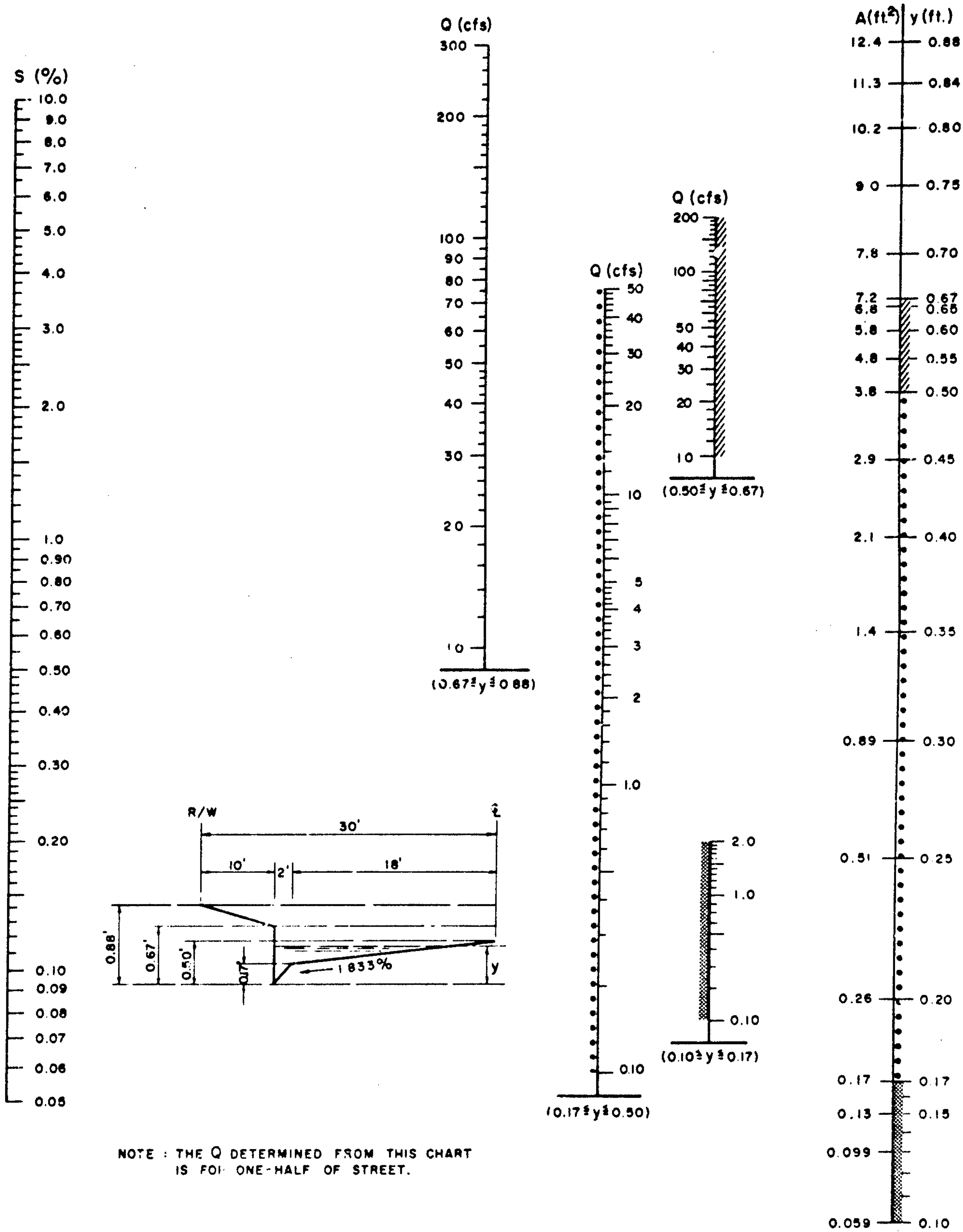
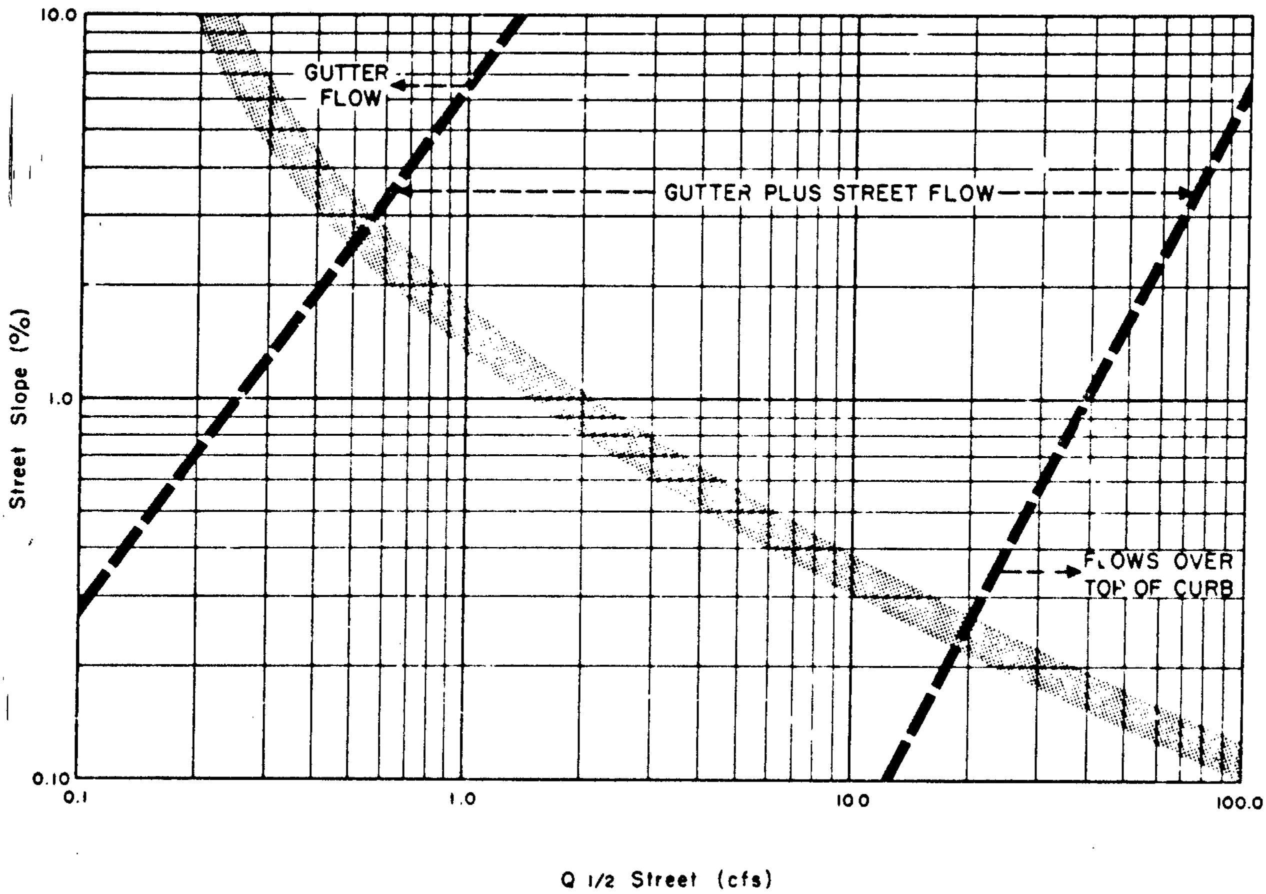


Figure 9.—NOMOGRAPH FOR STREET FLOW (14)

is necessary to determine not only the runoff which is contributory to a catch basin, but also the inlet capacity. Various types of catch basins exist and it is beyond the scope of this study to present all the available information regarding the inlet capacities of the many different types. Information on this subject is usually best obtained from local sources such as public works departments and flood control districts.

The major contribution of sediment to a particular inlet structure will probably be derived from the paved areas which contribute water directly to it. This is because the flows from these areas will be of sufficient depth and velocity to transport a significant quantity of the fallout material. Lawns, roofs, etc. will also contribute some sediment, but since these flows are mostly in sheet form, their ability to transport the fallout particles is low in comparison to the flows in the street.

It is evident that not all flows in the street can transport a significant amount of sediment. Based on Figure 3 and the nomograph in Figure 9, a plot of the street flows required to transport sediment at a significant rate have been presented in Figure 10. It is assumed for the purposes of this study that a transport rate, q_s, of 10^{-2} lb/sec/ft is significant. Figure 10 is subject to at least the same degree of reliability as Figures 3, 4, and 5 and is intended only to indicate a relative magnitude of required flows. Individual computations are the most desirable method of determining the transport rates for the various flows which may be experienced in a street or gutter. A basic assumption was made in the development of Figure 10 that the hydraulic characteristics of the flow cross section were the same as those assumed in the preparation of the sediment transport curves of Figures 3, 4, and 5. This assumption is reasonable in that the depth to width ratio is on the order of 1/40. The other basic assumption inherent in the development of Figure 10 is that the flows are over the top of a uniform sand bed. Of course, if the street is washed clean, this assumption is not valid. However, it is reasonable to assume that the initial conditions (before the sand is washed from the street surface) approach this limiting parameter of the sediment transport curves. The lack of a complete sand bed actually gives values of the rate of transport which are higher than actually experienced. This is because the maximum sediment transport occurs only when there is a bed of sufficient thickness to allow



NOTE: Based on particle diameter = 0.0025 feet and on street cross section shown on Figure 9...

Figure 10.— REQUIRED FLOWS FOR ONE-HALF STREET TO TRANSPORT SEDIMENT AT 10^{-2} lb/sec/ft

the flows to exert all of their available transport energy on particles. Therefore, if there are insufficient particles to use all of the available transport energy, the flow cannot transport the sediment at a maximum rate.

Transport by Wet Decontamination Procedures

The movement of sediment to an inlet structure can be effected by wet decontamination procedures such as the use of street-washers mounted on trucks or by the use of high pressure streams from firehoses. A stream of water from a firehose can wash approximately 10 sq ft per second[15], assuming the flow rate from the nozzle is 100 gpm (gallons per minute) and the hose pressure is 75 psi. Again, it is necessary to determine how the sediment load is presented to the inlet structure so that this supply rate can be compared to the transport rate.

It will be later shown, in the case of wet decontamination procedures, that the supply rate to the inlet structure is not primarily controlled by the transport capacity of the inlet structure, but is essentially controlled by the size and capacity of the connector pipe. This is particularly true in the case of small catch basins which have relatively small connector pipes on flat slopes.

Assuming that a typical catch basin would receive fallout from a decontaminated street area of approximately 15,000 sq ft, the total load to the inlet would be approximately 1,650 lb or 14.3 cubic feet. The washing rate from a firehose is assumed to be approximately 10 sq ft per second which would create 1.1 lb/sec of sediment transport. The washing rate of 100 gpm is equal to 0.223 cfs. From Figure 9 it can be shown that a street on a one percent slope causes a width of flow, for 0.223 cfs, of approximately two feet, and therefore $q = 0.112$ cfs/ft. Referring to Figure 3 the corresponding q_s is approximately 1.73×10^{-2} lb/sec/ft for a particle diameter of 0.0025 ft. This is equivalent to 3.46×10^{-2} lb/sec and is an extremely small fraction of the total load to be transmitted to the catch basin. In general, it can be concluded that most of the material transmitted to a catch basin during a wet decontamination process is transported by the impingement action of the high energy stream of water striking the particles.

As the fallout particles are moved to the inlet point they tend to pile up just in front of the point of impact of the stream of high velocity water. Eventually the major portion of the load will be pushed to the edge of the inlet to the drainage system. It is at this point that the critical transport rate into a catch basin occurs. The relative volumes of material and catch basin capacity will control, to a degree, the rate at which this pile of sediment may be washed in. The transport rate of the catch basin and/or the connector pipe will also control this rate.

Because the major portion of the fallout is washed to and into the inlet structure by the impingement action of the high pressure water stream from a firehose, it is obvious that the supply rate to such a structure will far exceed the transport rate which the structure is capable of creating. This is because the energy of the high-pressure stream from the hose far exceeds the energy which is created by the flows in the inlet structure. Therefore, sediment will tend to build up in these structures and care should be taken by personnel involved in decontamination procedures to insure the flushing of all of the deposited materials into the connector pipes flowing out of such structures.

<u>Transport of Fallout in Catch Basins</u>

The characteristics of the flow in a catch basin can be complex and vary greatly because of the many types of inlets and rates of flow that can be involved. During periods of low flow, when the water depth in the bottom of the catch basin is only a few inches, it may be assumed that the flows are of the same character as those in open rectangular or trapezoidal channels. As depths of flow increase, flow conditions are created that preclude using the previously developed data on fallout transport.

When low flows exist, it may be assumed the flow is analogous to open rectangular channel flow. Therefore, by assuming the slope of the bottom of the catch basin and knowing the flow rate (and therefore the flow rate per foot of width), the transport rate in the catch basin may be determined from Figures 3, 4, and/or 5. With the knowledge of the transport rate and the quantity of sediment deposited in the catch basin, the time required to flush the structure may be calculated.

When fallout material is deposited in a catch basin by wet decontamination procedures it can pile up in various ways. The procedure suggested above for determining the catch basin transport rate assumes the material is spread evenly over the bottom and does not totally block the entrance to the connector pipe. On the basis of this assumption the slope of the bed and of the bottom of the basin are considered as parallel. In actuality, the slope of the sand bed will vary greatly as the flow transports the sediment, and therefore, the rate of transport will change with time. However, this study assumes that the most probable slope of the bed will approach that of the bottom of the catch basin and that the transport rate will be constant.

Transport of Fallout in Pipes

This section presents the basic methods of analyzing the transport of fallout particles in pipes and of estimating the probable locations in the pipe system where sediment build-up may occur. As stated earlier, for the purpose of this study, the pipes are assumed to have sediment in the bottom one-third, which provides a sand bed and creates conditions allowing maximum sediment transport. It is assumed that the flow section above the bed is essentially rectangular and the friction of the side walls may be neglected up to a water depth of one-third the pipe diameter. These assumptions will permit analysis of drainage systems with at least the same accuracy as basic data may be predicted. A similar approach may be used for open channels, although the one-third pipe diameter criteria would not apply.

The procedure is to start the analysis at the upper end of the system, usually with a connector pipe, and continue downstream examining each reach of pipe in sequence. The transport rate of any pipe then becomes the sediment supply rate of the next section downstream.

The initial step in analyzing any given section of pipe is to determine the characteristics which control the hydraulics of the flow. These include the pipe diameter, slope, and coefficient of roughness. From these parameters and the rate of flow (either known or assumed) the Manning Formula may be used to determine the normal or uniform flow characteristics. The analysis requires the determination of the rate of flow for the pipe

flowing full from Figure 2 and then using Figure 11 and Table XVI, the characteristics of the "partial" flow can be determined. An example of this determination follows:

TABLE XVI (8)

THE TOP WIDTH OF A CIRCULAR CHANNEL FLOWING PARTLY FULL

Let $\frac{\text{depth of water}}{\text{diameter of channel}} = \frac{y}{D}$ and c = tabulated value. Then T = cD

$\frac{y}{D}$	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.000	.199	.280	.341	.392	.436	.475	.510	.543	.572
.1	.600	.626	.650	.673	.694	.714	.733	.751	.768	.785
.2	.800	.815	.828	.842	.854	.866	.877	.888	.898	.908
.3	.917	.925	.933	.940	.947	.954	.960	.966	.971	.975
.4	.980	.984	.987	.990	.993	.995	.997	.998	.999	1.000
.5	1.000	1.000	.999	.998	.997	.995	.993	.990	.987	.984
.6	.980	.975	.971	.966	.960	.954	.947	.940	.933	.925
.7	.917	.908	.898	.888	.877	.866	.854	.842	.828	.815
.8	.800	.785	.768	.751	.733	.714	.694	.673	.650	.626
.9	.600	.572	.543	.510	.475	.436	.392	.341	.280	.199

Example:

Given: Q = flow for pipe completely full

$Q_{1/3}$ = flow for pipe full to one-third diameter

$Q_{2/3}$ = flow for pipe full to two-thirds diameter

Q_x = flow for pipe when $D/3 \leq y \leq 2D/3$

Determine: The top width T for a flow on top of the assumed sand bed, assuming the flow depth is not greater than D/3

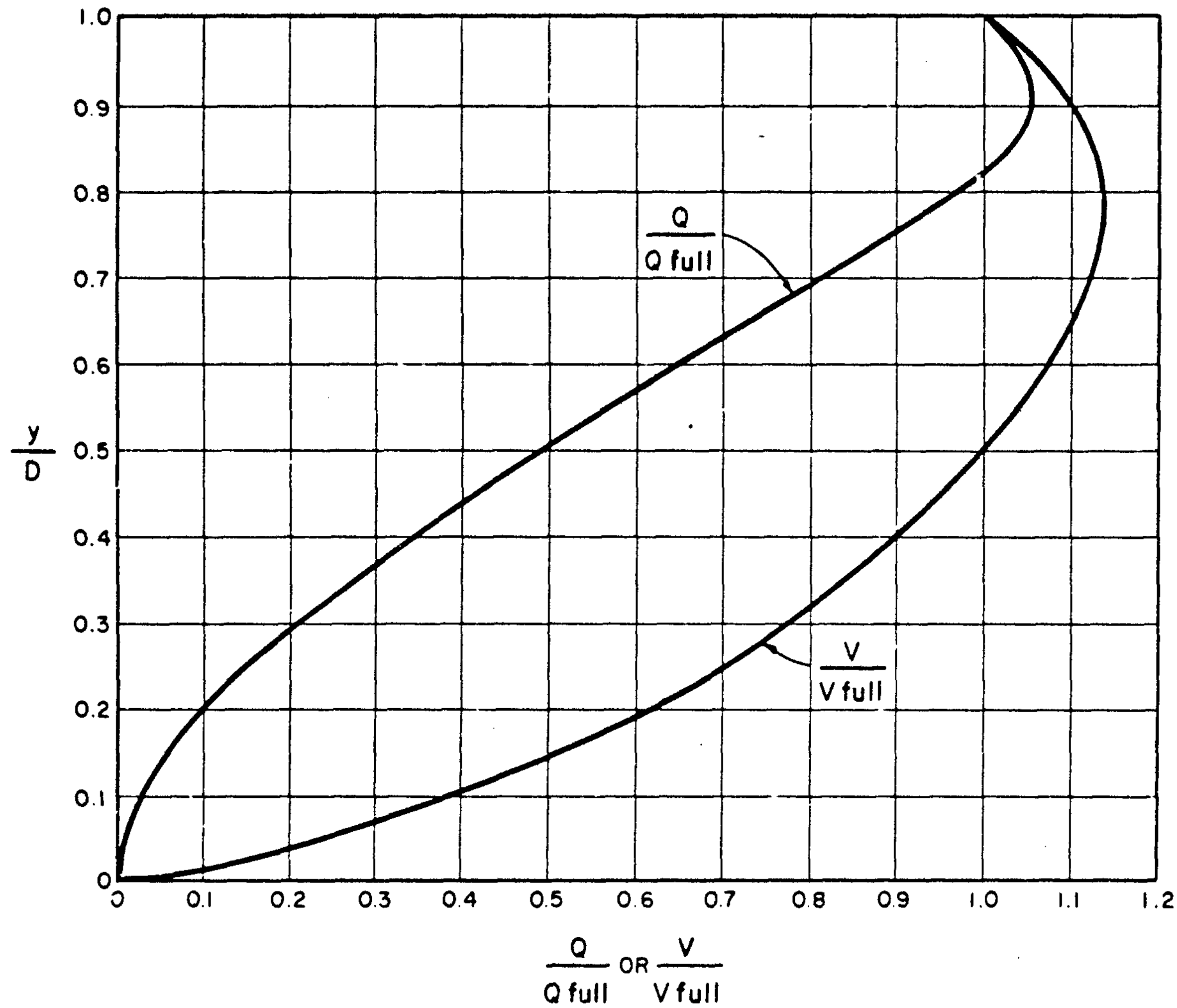
Solution:

(1) Determine Q from Figure 2

(2) Determine $Q_{1/3}$ from Figure 11

(3) Calculate $Q_x = Q_{actual} + Q_{1/3}$

(4) Determine y/D for Q_x



NOTE:

D = Nominal pipe diameter
y = Depth of flow
Q = Volume rate of flow
V = Mean flow velocity

Figure 11. — HYDRAULIC ELEMENTS OF PIPES FLOWING PARTLY FULL (16)

(5) Enter Table XVI and determine T_x for Q_x

(6) Determine T_{avg} from $T_{1/3}$ at $Q_{1/3}$ and T_x at Q_x

(7) Use T_{avg} to determine q, the rate of flow per unit width

The second step in analyzing the pipe is to enter Figures 3, 4, or 5 (depending on the particle diameter which is being considered) and determine q_s, the transport rate per foot of width. Multiplying the transport rate by T_{avg} gives the total rate of transport for that section, G, in pounds per second. This transport rate then becomes the supply rate for the next downstream section of pipe.

As mentioned earlier, the bed-load equations assume that a given transport rate occurs when a state of equilibrium has been reached. Therefore, it follows that when the transport rate of a given reach of pipe is less than the supply rate the build-up of sediment will begin at the upper end of the reach and proceed downstream. As the sediment load is deposited along the reach the transport mechanism will approach equilibrium; and if the reach of pipe is long enough, the full state of equilibrium will be attained. This points to the fact that the upper reaches of a pipe will receive the maximum rate of deposit and will therefore tend to be the sections which might clog first.

As the sediment builds up beyond the one-third depth initially assumed, the ability for any given flow to transport sediment diminishes because the effective width, T_{avg}, increases and therefore both q and q_s decrease. This continues until the depth of sediment increases to the point where it is at one-half the pipe diameter. Above the one-half point the situation reverses because T_{avg} decreases with increasing depths of sediment.

It was assumed earlier in this study that fallout washed into a system at any one point, consisted essentially of particles of one diameter. This was assumed to have been caused by the wind-created segregation. On the other hand, if the local fallout contains the full range of grain sizes, such segregation will occur during the surface washing process and also in the drainage system. The finer particles, being transported at higher rates, will travel faster and will soon outdistance the larger particles. This is particularly true when the fines are carried in complete suspension.

When flows diminish and eventually cease, the rate of sediment build-up is increased. For this reason it is important to continue wet decontamination procedures long enough to allow the sediment to be spread out over a long length of the system. If debris enters a system during storm flows, it will have the effect of interrupting the process of the transport rate attempting to reach a state of equilibrium. The debris will act as a dam and cause sediment to build up behind it and will increase the probability that any section of the drainage system will clog.

Wet decontamination operations create initial unit transport rates which are much higher (because of the energy of the high pressure flows impinging on the particles) than those experienced from normal rainfall. Also, the rates of flow from wet decontamination operations are usually significantly less than storm water flows. Therefore, wet decontamination procedures create the most critical sediment problems -- at least in those localized areas where decontamination is being carried out. However, because these washing operations will probably be carried out in isolated cases, fairly well separated in time and distance, the net effect on the total drainage system (and therefore the net effect to postattack recovery) is expected to be negligible.

Connector pipes flowing out of catch basins are usually of small diameter and constructed on steeper slopes than the main lines. For these reasons they will have higher velocities of flow and therefore higher transport rates than the main lines. Therefore, sediment probably will build up in main lines just downstream of the points of inlet from the connector pipes. Sediment transport capacities of connector pipes effectively control the supply rate to them from catch basins during wet decontamination operations. This is because the sediment fills the bottom of the basin and must be washed into the connector pipe at a rate that will preclude clogging.

The drainage system for a given area actually provides a large storage volume for sediment. At the assumed surface mass loading of 0.11 lb/ft^2 and unit weight of 115 lb/ft^3, one acre of area theoretically contains approximately 41.7 cubic feet of fallout. A 24-inch diameter pipe, 26.5 feet long, one-half full would contain that volume of fallout. Therefore, it is obvious that most drainage systems could store the sediment, if it can

be washed into the system in a manner that precludes plugging. If wet decontamination procedures can be started at the downstream end of the system (which of course is not the case for storm flows) then the capacity of the system to store the material could be used to its maximum extent. Later the sediment would be removed -- very slowly with low flows and faster during peak storm runoff.

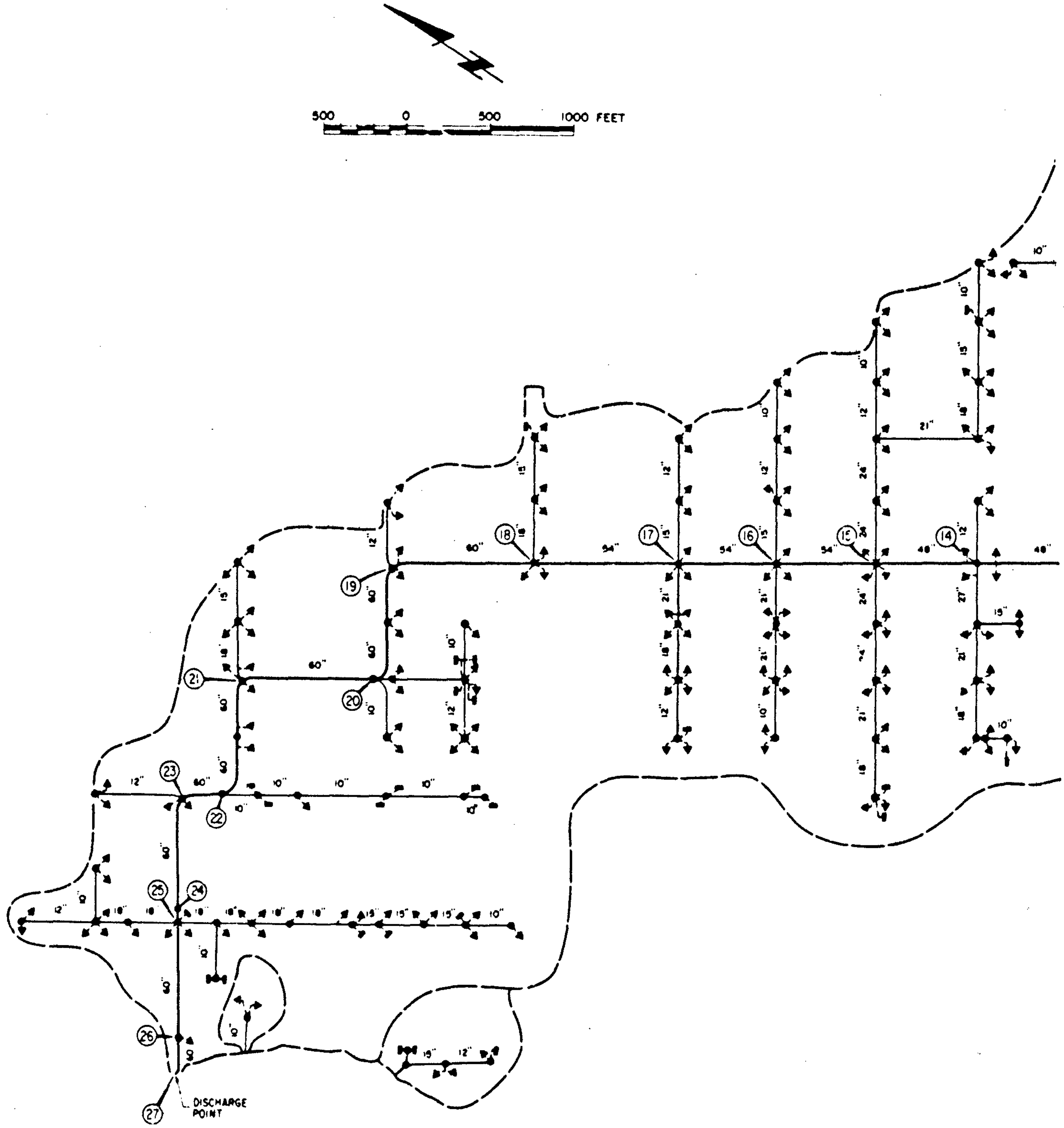
ILLUSTRATION OF THE USE OF THE ANALYSIS

The next section of this study is an illustration of how to apply the method of analysis to an actual drainage system to determine the sedimentary effects of fallout on that system. The purpose of the illustration is to test the method and to develop more information regarding the effects of the sediment which can only be derived from analyses of actual systems. A test area has been chosen, and examples will be shown, assuming that fallout is transported to the system both by natural rainfall and because of wet decontamination operations.

Test Area

The drainage area chosen is part of the storm drain system of the City of San Jose, California. Figure 12 represents the essential elements of the test area and Figure 13 shows the details of the system's typical catch basins. The main outfall line of the test system is noted on Figure 12 with numbers indicating the various points on the outfall which will receive incremental flows from the laterals. Table XVII provides additional detailed data on the system comprising the pipes.

It is interesting to note that an inverted siphon exists on the main outfall between stations 24 and 26. It consists of a 60-inch R.C.P. (reinforced concrete pipe) laid flat between stations 24 and 25. Between stations 25 and 26 there is a vertical curve, approximately 55 feet long, which gains the grade needed to start the down-slope into station 26. At station 24 there is a drop-manhole which causes the flows to drop several feet into the bottom of the flat section of pipe between stations 24 and 25. This inverted siphon makes a sediment trap and would undoubtedly become plugged if low flows carrying sediment continued for a significant time.



500 0 500 1000 FEET
DISCHARGE POINT

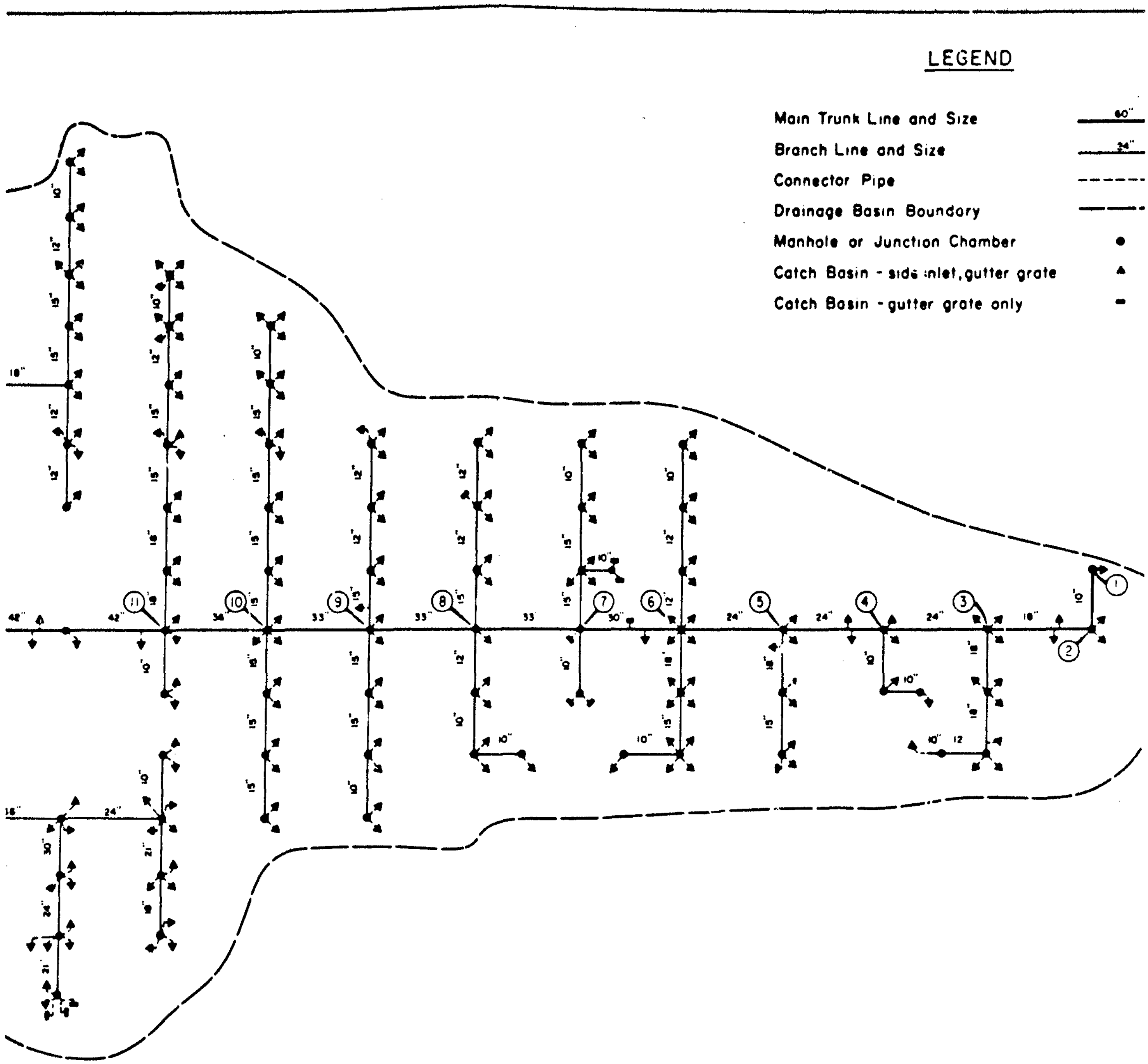


Figure 12. - TEST AREA FOR FALLOUT TRANSPORT ANALYSIS

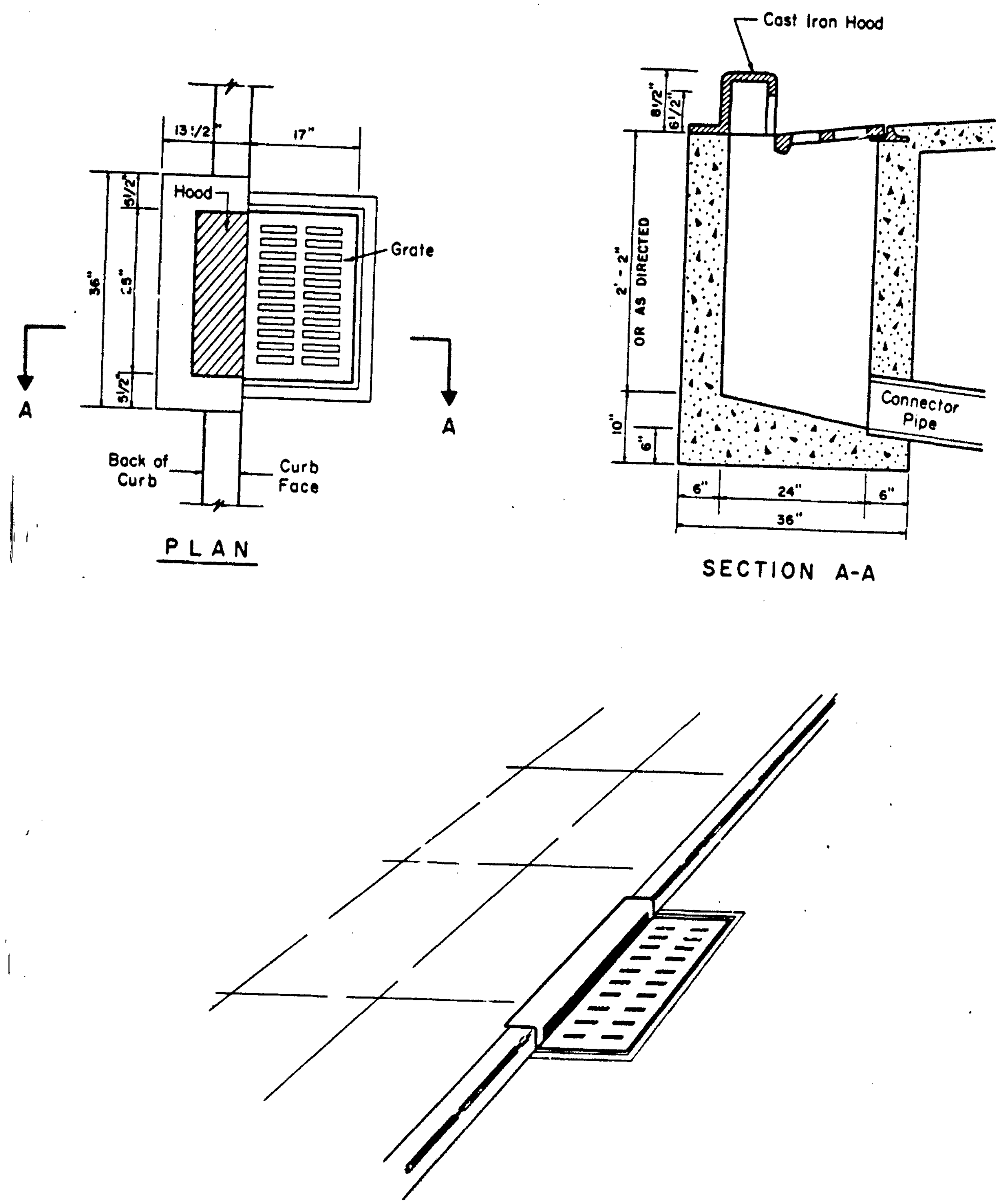


Figure 13. — TYPICAL CATCH BASIN IN TEST AREA DRAINAGE SYSTEM

TABLE XVII

TEST DRAINAGE SYSTEM CHARACTERISTICS

Stations	R.C.P. Diam. (inches)	Length (ft)	Slope (%)
1-2	10	345	0.40
2-3	18	627	0.51
3-4	24	598	0.18
4-5	24	611	0.25
5-6	24	612	0.46
6-7	30	642	0.26
7-8	33	630	0.20
8-9	33	639	0.29
9-10	33	624	0.66
10-11	36	611	0.28
11-12	42	1,255	0.15
12-13	42	643	0.25
13-14	48	760	0.22
14-15	48	603	0.29
15-16	54	612	0.20
16-17	54	623	0.22
17-18	54	875	0.23
18-19	60	931	0.16
19-20	60	693	0.135
20-21	60	858	0.15
21-22	60	708	0.15
22-23	60	317	0.22
23-24	60	715	0.12
24-25	60	43	Zero
	60	55	-15.68
25-26	60	595	0.13
26-27	60	206	0.13

The test drainage area contains approximately 772 acres. The average slope of the terrain in the northerly direction is about 0.3 percent. There are 377 catch basins on the system and approximately 90 percent of them are of the type shown on Figure 13. The area is considered well built up and a runoff coefficient, c, of 0.6 is assumed to be reasonably representative of the entire area.

Rainfall data [17] indicate the adjusted mean annual precipitation for the area is 14.6 inches. For storm durations of 15 minutes the intensities are one inch per hour for a two year storm and two inches per hour for a 100 year storm.

Most of the streets in the area are paved 30 feet wide between curbs within a 60 foot right-of-way. The typical pavement for these streets is asphaltic concrete. Grades of the streets are on an average of 0.2 to 0.4 percent.

The areas which contribute drainage to the catch basins average 2.29 acres for each catch basin. Because these areas are relatively small, the time of concentration for flows to the catch basins is assumed to be 15 minutes or less. The catch basin inlet capacity is limited to a maximum of 2.0 cfs because of the small open area in the cast iron gutter grating. Again, because of the small inlet capacity of the catch basins, the connector pipes are eight inches in diameter in almost all cases.

Referring to the runoff formula, $Q = ciA$, and the average drainage area to each catch basin of 2.29 acres, the peak runoff to each catch basin is 1.38 cfs ($Q = 0.6 \times 1 \times 2.29 = 1.38$) for a rainfall intensity of one inch per hour. Obviously, the maximum sediment carrying flows will be limited to 2.0 cfs for each catch basin because this is the maximum inlet capacity of the basin.

All of the pipe in the system is R.C.P. and the roughness factor, n, is assumed to be 0.013 in all cases.

Wet Decontamination Procedure - Problem Analysis

The area to be considered for this illustration is the southerly side of the street between stations 1 and 2, as shown on Figure 12. This area is assumed to be washed, by one firehose, into the catch basin that flows into the manhole at station 1.

$$A = 15 \text{ ft} \times 325 \text{ ft} = 4{,}870 \text{ sq ft}$$

The slope, S, of the gutter along the southerly side of the street is:

$$S = \frac{105.88 - 105.67}{325} \times 100 = 0.0645 \text{ percent}$$

Transport of Fallout to Catch Basin

Particle diameter, d_{50}, = 0.0025 ft

Surface Mass Loading, J, = 0.11 lb/sq ft

Washing rate of one fire hose at 100 gpm (0.223 cfs) is
10 sq ft/sec or 1.1 lb/sec

Pavement surface is asphaltic concrete

n for the gutter is 0.013

By inspection of Figure 3, it can be seen that the transport of fallout by gutter flows is negligible in this case and that the entire sediment load must be transported to the catch basin by the impingement action of the water from the firehose. The amount of fallout thus transported and eventually piled at the point of inlet is:

$$\text{Volume of Fallout} = 4{,}870 \times 0.11 \times 1/115 = 4.75 \text{ ft}^3$$

The volume of the catch basin is approximately:

$$\text{Volume of Catch Basin} = 2.0 \times 2.0 \times 2.5 = 10 \text{ ft}^3$$

From the above, it can be seen that if the material was instantaneously pushed into the catch basin it would fill one-half of the basin and clog the entrance to the connector pipe. Therefore, the rate that the sediment should be transported from the catch basin into the connector pipe is equal to the transport capacity of the connector pipe.

Transport of Fallout in Connector Pipe

Pipe diameter, D, = 8 inches

$S = 0.10$ ft/ft, $Q = 0.223$ cfs, $n = 0.013$

Assume the bottom one-third of the pipe is full of sediment

From Figure 2, $Q_{full} \cong 3.53$ cfs

$$Q/Q_{full} = \frac{0.223}{3.53} = 0.632$$

From Figure 11:

$$Q_{1/3} \text{ at } y/D = 0.33 \text{ is } 0.25\, Q_{full} \cong 0.88 \text{ cfs}$$

$$Q_x = Q + Q_{1/3} = 0.223 + 0.88 = 1.10 \text{ cfs}$$

$$\text{For } Q_x = 1.10,\ \frac{Q_x}{Q_{full}} = \frac{1.10}{3.53} = 0.312 \text{ and, } y/D = 0.375$$

From Table XVI, T = 0.968D and therefore,

$$q = \frac{Q}{T_{avg}} = \frac{Q}{0.96D} = \frac{0.223}{0.96 \times 8/12} = 0.347 \text{ cfs/ft}$$

From Figure 3, determine q_s:

$$q_s = 2.7 \text{ lb/sec/ft and,}$$

$$G = 2.7 \times 8/12 \times 0.96 = 1.73 \text{ lb/sec}$$

Because there are 536 pounds of sediment to be washed into the connector pipe at a rate not to exceed 1.73 lb/sec, the required washing time is:

$$\text{Required Washing Time} = \frac{536}{1.73} \Big/ 60 = 5.16 \text{ minutes}$$

Therefore, it will require approximately five minutes to wash the material piled in front of the catch basin in order to prevent clogging the connector pipe.

Transport of Fallout in Pipes

Following, in Table XVIII, are tabular computations showing the supply and transport rates in the pipes downstream of the subject connector pipe.

TABLE XVIII

TRANSPORT CAPACITIES FOR TEST EXAMPLE

Location	Pipe Diam. (inches)	Slope (ft/ft)	Q_{full} (cfs) (a)	Q (cfs)	$Q_{1/3}$ (cfs)	Q_x (cfs)
1-2	10	0.0040	1.4	0.223	0.35	0.57
2-3	18	0.0051	7.5	0.223	1.88	2.10
3-4	24	0.0018	10.0	0.223	2.50	2.72

Location	Q_x/Q_{full}	y/D	T_{avg} (ft)	q (cfs/ft)	q_s lb/sec/ft	Transport Rate, G (lb/sec)
1-2	0.41	0.44	0.81	0.28	5×10^{-4}	4×10^{-4}
2-3	0.28	0.36	1.42	0.16	Negligible	--
3-4	0.27	0.35	2.11	0.10	Negligible	--

(a) Assumes n = 0.013 for all pipes

A comparison of the transport rate in the 10-inch pipe with the supply rate of 1.73 lb/sec from the connector pipe indicates that a build-up of sediment will occur at the outlet end of the connector pipe and that the 10-inch pipe will probably clog. This would be particularly true if the wash water was stopped at the end of the five minutes required to flush the material into the connector pipe.

Natural Rainfall - Problem Analysis

The problem of analyzing the sedimentary effects of fallout on a drainage system during a storm is similar to the problem of designing the system initially. Based on the hydrology of the area, it is necessary to start at the upstream end of the system and work downstream, considering the times of concentration of the various flow increments that comprise the total flow. As the flows are accumulated the design of the conduits is prepared based on such design parameters as allowable slopes and pipe diameter. The times of concentration for the various flows become important because the total flow must represent the peak which may occur when the water from the point farthest from the outlet is contributing to the main line. However, this may occur at a point later in time than when some other section of the system is contributing its peak flows. In effect, the problem is one of considering the peak flows for each branch of the main system separately and then considering the combined effects of these branch flows.

However, for the purposes of initially analyzing the effects of fallout on such a system, certain assumptions may be made to simplify the method of analysis. These assumptions will allow a reasonable assessment of the problem and maintain a degree of accuracy consistant with that of the basic data.

Assuming the drainage basin under consideration has the same general slopes, runoff coefficients, etc. throughout, then an analysis of one segment of the area will provide a reasonable indication of the degree of problems to be experienced by other sections of the drainage basin.

The test area chosen for this example has fairly consistant hydrological characteristics. The average area draining to each catch basin is approximately 2.29 acres which contributes on the order of 1.5 cfs of

storm water flow. Essentially each one of the catch basins in the test area receive flows from one-half of a typical block. As mentioned earlier, the streets in the area are on an average slope of 0.2 percent to 0.4 percent and consist of asphaltic concrete 30 feet wide between curbs. Figure 13 shows the details of a typical catch basin in the drainage system which has a maximum inlet capacity of approximately two cfs.

The rate of flow to an inlet structure will determine the rate of sediment supply to that structure and therefore is the first item to determine. From the above information, the flow to a typical catch basin is about 1.5 cfs which is less than the inlet capacity of the basin. Assuming the street grade is 0.4 percent and the flow is 1.5 cfs (which is the flow for one-half of the street cross section) an indication of the relative significance of the transport rate may be obtained from Figure 10. For this example it indicates that the transport rate is significantly less than 10^{-2} lb/sec/ft. Figure 9 shows that the depth of flow, measured from the gutter flow-line, is 0.30 feet, and the width of flow is approximately 9 feet. The total transport rate is therefore less than 9×10^{-2} lb/sec which is negligible in comparison to the transport rate of about 1.73 lb per second created by the wet decontamination operations in the connector pipe of the previous example. A comparison of the concentrations of sediment is as follows:

Wet Decontamination Operation:

$$\text{Concentration in Connector Pipe} = \frac{1.73 \text{ lb/sec}}{0.223 \text{ ft}^3\text{/sec}} = 7.78 \text{ lb/ft}^3$$

Natural Rainfall:

$$\text{Concentration in Street Flow} \leq \frac{9 \times 10^{-2} \text{ lb/sec}}{1.5 \text{ ft}^3\text{/sec}} \leq 0.06 \text{ lb/ft}^3$$

From the above analysis and comparison, it may be concluded that the sediment transport rate, due to the assumed natural rainfall in the test area, will not create any serious clogging effects in the drainage system under consideration. Further analysis of this system is therefore not justified.

EFFECTS OF FALLOUT

The single most important variable in the whole question of fallout transport is the size of the particle. A change in this factor can change the results of the analysis more significantly than any other factor and therefore should be chosen with the greatest care.

The relative difference in the transport rate and the supply rate for any given flow is the basic indicator of whether a problem will be created by the fallout. Usually, sedimentation will occur when the flow rate per unit of width is changed from a high to a low value, such as in the case of water entering a catch basin, or in the case of water entering a main line from a connector pipe.

Wet decontamination procedures are more likely to create sediment build-up than storm flows because they consist of water at high velocities being used for a relatively short time. It is important that the wet decontamination procedures be used long enough to flush the fallout into the system. Systems have a vast volume of storage for fallout which can be used effectively only if the material is properly washed into them.

During the progress of this study several areas of the problem arose which justify more extensive study than was available within the scope of work of this project. The transport of the fallout particle by overland sheet flows created by rainfall and by storm flows in streets should be studied in depth. It is recommended that sediment transport through catch basins and through pipes flowing under pressure be given further study. More experimental data on all phases of fallout transportation is needed in order to check the accuracy of the theoretical method of analysis. Also, it is recommended that various other actual drainage systems be analyzed to develop a more complete picture of the sedimentary effects of fallout.

There will probably be relatively few occurrences of sediment build-up from sediment being washed into a drainage system, and these instances will not seriously damage the gross effectiveness of the systems functional capacity.

APPENDIX I

LIST OF REFERENCES

(1) "Postattack Sanitation Waste Disposal, Pest and Vector Control Requirements and Procedures." By Engineering-Science, Inc., for the OCD, Office of the Secretary of the Army, Department of the Army. Subtask 3441A, Contract No. OCD-PS-64-9, February 1965.

(2) "The Effects of Nuclear Weapons." U. S. Government Printing Office, Washington, D.C., Feb. 1964.

(3) "Background of Civil Defense and Current Damage Limiting Studies." By Joseph Romm. Department of Defense, Office of Civil Defense, TR 35, June 1966.

(4) "The Use of Aircraft in the Control of Mosquitos." By the American Mosquito Control Association, March 1948.

(5) "Open Channel Flow." By F. M. Henderson. MacMillan Book Co., New York, First Ed., 1966.

(6) "Engineering Hydraulics." By H. Rouse. John Wiley and Sons, Inc., New York, 1950.

(7) "The Bed-Load Function for Sediment Transportation in Open Channel Flows." By H. A. Einstein. U. S. Department of Agriculture Technical Bulletin No. 1026, September 1950.

(8) "Handbook of Hydraulics." By H. W. King. McGraw-Hill Book Co., New York, Fourth Ed., 1954.

(9) "Design Division Standards For Structural and Hydraulic Design of Flood Control Projects." Los Angeles County Flood Control District, Los Angeles, California, Second Edition, December, 1958.

(10) "Transport of Sediment Mixtures With Large Ranges of Grain Sizes." By H. A. Einstein and N. Chien. Corps of Engineers, Missouri River Division, Sediment Series No. 2, 1953.

(11) "Hydraulics of Runoff From Developed Surfaces." By C. F. Izzard. Proceedings of the Highway Research Board, Vol. 26, pgs. 129-150, 1946.

(12) "Studies of Raindrop Erosion." By W. D. Ellison. The Agricultural Engineer, Vol. 25, 1944.

(13) "Some Effects of Rain Drops and Surface Flow on Soil Erosion and Infiltration." By W. D. Ellison. Trans. of Am. Geophysical Union, Vol. 26 III.

(14) "Hydrology and Hydraulic Design Manual." Los Angeles County Flood Control District, Los Angeles, California, November 1964.

(15) "Handbook for R.diological Monitors." Office of Civil Defense, Dept. of Defense FG-E5.9, April 1963.

(16) "Elementary Fluid Mechanics." By J. K. Vennard. John Wiley and Sons, Inc., New York, Third Edition, 1955.

(17) "Hydrologic Atlas, Santa Clara County, California." By C. E. Bradbury and Associates. For Santa Clara County Flood Control and Water District, 1964 Revision.

(18) "Refuse Collection and Disposal Practice -- Reported Problems, Discussions and Trends." 1965 Refuse Collection Com. and Am. Public Works Assoc. and U. S. DHEW, PHS Mimeo, 1956.

(19) "Removal of Simulated Fallout From Pavements by Conventional Street Flushers." By D. E. Clark, Jr. and W. C. Cobbin. USNRDL - TR - 797, 18 June 1964.

(20) "Performance Characteristics of Wet Decontamination Procedures." By W. L. Owen, J. D. Sartor, and W. H. Van Horn. USNRDL - TR - 335, 21 July 1960.

(21) "Radiological Recovery of Land Target Components -- Complex III." By W. L. Owen and J. D. Sartor. USNRDL - TR - 700, 20 November 1963.

(22) "Cold Weather Decontamination Study - McCoy I." By J. C. Maloney and J. L. Meredith. U. S. Army NDL - TR - 24, January 1962.

(23) "Erosional Topography and Erosion." By James M. Little, E.M. A. Carlisle & Co., 1940.

(24) "Laboratory Investigation of Flume Traction and Transportation." By Y. L. Chang. Trans. ASCE, Vol. 104.

(25) "Relation Between Rainfall and Runoff from Small Urban Areas." By W. W. Horner and F. L. Flynt. Trans. ASCE, Vol. 101.

(26) "Method of Predicting Runoff From Rainfall." By Ray K. Linsley, Jr. Trans. ASCE, Vol. 107.

(27) "Surface Runoff Determinations From Rainfall Without Using Coefficients." By W. W. Horner and S. W. Jens. Trans. ASCE, Vol. 107.

(28) "A Method of Computing Urban Runoff." By W. I. Hicks. Proc. Am. Soc. of Civil Engs., Vol. 109.

(29) "Refuse Disposal Needs Study." By Assoc. of Bay Area Governments for the California State Dept. of Public Health, 1965.

(30) "Effects of Fire on Structural Debris Produced by Nuclear Blast." By J. Rotz, J. E. Edmunds, and K. Kaplan. URS Corp., URS 639-9, 1965.

(31) "An Engineering Concept of Flow in Pipes." By Charles W. Harris. Trans. ASCE, Vol. 115.

(32) "Open-Channel Flow at Small Reynolds Numbers." By L. G. Straub, Edward Silberman, and H. C. Nelson. Trans. ASCE, Vol. 123.

(33) "The Present Status of Research on Sediment Transport." By Ning Chien. Trans. ASCE, Vol. 121.

(34) "Fallout and Radiological Countermeasures." By Stanford Research Institute. OCD, DOD, Vol. I and II, January 1963.

(35) "Some Relationships Among Particle Size, Mass Level and Radiation Intensity of Fallout From a Land Surface Nuclear Detonation." USNRDL - TR - 639, 21 March 1963.

(36) "Design Criteria for Roof Washdown." USNRDL - TR - 789, 11 August 1964.

APPENDIX II

LIST OF SYMBOLS

Symbol	Definition	Units or Dimensions
A	area	ft^2 or acres
D	nominal pipe diameter	ft
G	dry weight rate of sediment transport	lb/sec
J	surface mass loading of fallout	lb/ft^2
Q	volume rate of flow	cfs
R	hydraulic radius	ft
R_b	hydraulic radius with respect to sand bed	ft
S	slope of bottom	ft/ft
S_e	slope of energy gradient	ft/ft
T	top width of a circular channel flowing partly full	ft
V	mean velocity of water	ft/sec
b	bottom width of open channel	ft
c	runoff factor or constant	none
d_m	mean particle diameter	ft
d_{35}	diameter of particle which has 35 percent of the total sediment load which is of smaller particle diameter	ft
g	acceleration due to gravity	ft/sec^2
i	rainfall intensity	inches/hr
n	manning roughness coefficient	none
q	rate of flow per unit width	cfs/ft
q_s	weight rate of sediment transport per unit width	lb/sec/ft
s_s	specific gravity of sediment	none
s_w	specific gravity of water	none
y	depth of flow	ft

Symbol	Definition	Units or Dimensions
y_m	mean depth of flow	ft
γ	specific weight	lb/ft^3
γ_s	compacted unit weight of fallout	lb/ft^3
ρ	density	$slugs/ft^3$
ρ_s	density of sediment	$slugs/ft^3$
Φ	intensity of transport	none
ψ	intensity of shear	none

SUMMARY

The objectives of this study are to examine, in depth, a specific geographical area and to: (1) develop the magnitude of the postattack sanitation requirements; (2) develop the character of effective postattack sanitation procedures; (3) present a time sequence for implementing the procedures; and (4) assess the effectiveness of the proposed countermeasures. Further objectives are to develop information concerning: (1) the sedimentary effects of fallout washed into municipal drainage systems; (2) the sediment concentrations of flows reaching the system; (3) the location and probability of potential stoppages; and (4) the flows required to eliminate sediment deposition.

SANITATION RECOVERY

The San Jose Metropolitan Area was selected as the Study Area in which to apply and test the postattack sanitation recovery techniques developed in Phase I under an earlier contract (OCD-PS-64-9). Although this report is not intended to be part of the Five City Study, Weapon 154 of the Five City Study Scenario was applied to the Study Area to establish a postattack environment because of the readily available information on the City of San Jose.

The preattack solid organic waste production in the Study Area is estimated to be approximately 7,700 cubic yards per day during the summer months. Approximately 3,000 cubic yards of the total are wastes from the local canneries. Regular sanitation companies and special cannery waste haulers use 226 trucks and 440 men in the collection of these wastes. The regular companies normally work 5.5 days per week (44 hours per week), while the special companies work about 20 hours per day, seven days per week. There are 13 disposal sites in the Study Area which require 25 crawler-type tractors, eight draglines, and 35 men to operate them preattack. Mosquito, fly, and rodent control operations are guided by the local health departments, with much of the work being performed by private exterminator companies and individual householders.

Based on the assumed weapon effects, approximately 60 percent of the waste collection vehicles, 40 percent of the tractors, 100 percent of the draglines, 70 percent of the sanitation company offices and 30 percent of the vehicle maintenance buildings will be damaged to a degree that will preclude their use early postattack. It is assumed that about one-half of the surface roads will be impassable to vehicles due to debris.

This study assumes there will be no nightsoil production because the population will leave shelters when they realize that no fallout has been created by the assumed weapon. It is estimated that a minimum of 68,500 cubic yards of solid organic waste would require collection and disposal in the first week postattack. This would create the following logistical requirements: (1) 150 collection vehicles working 16 hours per day for seven days; (2) 13 tractors; (3) 8,300 gallons of fuel; and (4) 642 workers.

FALLOUT TRANSPORT

The development of information regarding the sedimentary effects of fallout on drainage systems is based on the fundamental assumption that the transport of this sediment is analogous to the familiar bed-load movement which occurs in the sand beds of natural streams. All components of the drainage system are assumed to have a sand bed over which a relatively shallow and wide flow of water is traveling. From this basic assumption, and the application of Einstein's theories(7), curves have been developed which show sediment transport rates as functions of particle diameter, rate of flow per unit of width, and conduit slope. On the basis of the same theory and assumption, curves have been developed which give the hydraulic characteristics for various flow rates, slopes, and particle diameters.

Flows originating from natural rainfall or wet decontamination procedures are studied in three phases: (1) fallout transport to an inlet structure; (2) transport through the inlet structure; and (3) transport in the pipes comprising the system.

CONCLUSIONS

The logistics of the postattack sanitation operations are impeded by the damage effects of the assumed weapon. The collection and disposal of solid organic wastes should receive the first priority, followed by mosquito and fly control. Because of a possible lack of fuel and an estimated 30 percent deficiency in the number of vehicles required to collect the predicted wastes, there is expected to be a significant amount of uncollected wastes in the Study Area at the end of the first week postattack. This will create favorable fly breeding conditions. However, the enteric diseases, which flys can transmit, will not be as detrimental to the surviving population as they could be if the flys had access to uncollected nightsoil from shelters. A well formed operational plan and administrative organization are necessary to fully implement the suggested procedures. However, the gross effect of the deficient sanitation capabilities, expected to be available in the Study Area postattack, probably will not create a disease incidence level which would seriously damage postattack recovery.

The parameter which can cause the greatest variation in the sediment transport rate is the fallout particle diameter. The relative difference in the sediment transport and supply rates for a particular section of a system is indicative of whether or not sediment build-up will occur. Sediment deposition will occur when the rate of flow per unit of width is reduced, as in the case of water entering a catch basin from a gutter or entering a main line from a connector pipe. Wet decontamination procedures are more likely to create sediment build-up than storm flows because of their high velocity and relatively short duration. There may be a few occurrences of sediment build-up from fallout being washed into a drainage system, but these instances probably will not damage the gross effectiveness of the system's functional capability.

It is recommended that further study and analysis be given to: (1) the transport of fallout by overland sheet flow created by rainfall; (2) the transport by storm flows in streets; and (3) additional actual drainage systems to develop more data on the sedimentary effects of fallout.

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13. ABSTRACT

This study presents information on the magnitude, character, and timing of postattack sanitation operations for the San Jose Metropolitan Area of California and assesses the effectiveness of these overall operations on maintaining disease incidence at levels which will not be detrimental to postattack recovery. It also presents information on the sedimentary effects of fallout washed into drainage systems including: (1) a method to determine the effects; and (2) the sections of the systems which are most likely to experience sediment build-up. (U)

The results of the analysis of the postattack sanitation operations in the Study Area indicate approximately 60 percent of the waste collection vehicles will be damaged, but due to increased use of the surviving vehicles and the postattack reduction of household refuse production, no detrimental effect on the overall postattack recovery of the area is expected. (U)

The study of fallout transport in drainage systems indicates that sediment build-up will occur when the flow rate per unit of width is decreased, as in the case of water exiting from a catch basin connector pipe into a main line. (U)

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14 KEY WORDS	LINK A		LINK B		LINK C	
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fallout transport						
organic wastes						
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